THE ENGINEER

A Seven-Day Journal

Metal Finishing Productivity Report

The Anglo-American Council on Productivity has now issued the report of the specialist team which visited the United States to examine productivity in metal finishing. The team visited twenty-one factories in the course of its investigation and it covered a wide field of the subject, including paint finishing and electro-plating and certain related processes, such as anodising, bright dipping and metal colouring. In the report the team states that the conditions of economic prosperity and free marketing in the United States have led to keen competition and that the value of an attractive finish in promoting sales is generally recognised. All ranks in industry appeared to be cost-conscious, and the workers took pride in operating expensive machinery and saw prospects of greater prosperity in increased mechanisation. On the technical side comparatively little was found that was not known and practised by the larger and more progressive firms in this country. As with this country, there was a lack of liaison between the design and finishing departments, and only in rare cases were the latter departments consulted at any stage in the design of a product. A point of some note brought out in the report was that in the United States, for articles not subjected to close-range scrutiny, a lower standard of finish was adopted, and, as long as performance did not suffer, minor imperfections and blemishes were tolerated. Process control was recognised at all levels as a vital part in manufacture, and inspection in general was good, particularly at the early stages of manufacture. Although greater attention appeared to be given to reduce operator fatigue in America, the prevention of accidents and maintenance of healthy working conditions, it was considered, were subordinated to the demands of production.

King's College, Newcastle upon Tyne

On Wednesday last, November 28th, there was an impressive ceremony at King's College, Newcastle upon Tyne, when the Stephenson Building was officially opened by H.R.H. The Duke of Edinburgh, K.G., F.R.S. His Royal Highness was received in Newcastle by Viscount Allendale, Lord Lieutenant of Northumberland, Alderman W. McKeag, the Lord Mayor, Lord Eustace Percy, Vice-Chancellor of the University of Durham and Rector of King's College, Viscount Ridley, chairman of the council of King's College, and by Sir Claude Gibb. Immediately before the ceremony the honorary degree of Doctor of Civil Law was conferred upon His Royal Highness by the Vice-Chancellor of the University of Durham. The establishment of schools in agricultural, chemical and production engineering and fuel technology within the department of mechanical and marine engineering has greatly increased the demands for additional laboratory and workshop space at King's College, in recent years, and the design of the new engineering block was begun in 1946, when it was decided to provide accommodation for a total of 650 students. The site occupied by the new building was made available to King's College through the kindness of the Freemen of the City of Newcastle upon Tyne and the City Council, and work was started in January, 1949. The building, for which Messrs. Edwards and Manby were the architects, and Leslie and Co., Ltd., the main contractors, was completed in April last. During its construction the council of King's College decided that it should be named "The Stephenson Building," as a memorial to George Stephenson, who lived for some time within a stone's throw of the site. The building consists of three main parts—a large five-storey main block with a southern aspect and two wings, each of two storeys, the northern ends of the two wings being linked together and thus enclosing a small courtyard. Most of the ground floor is occupied by laboratories, workshops and a number of small rooms designed for individual research projects. The lecture rooms, reading-room and classrooms are situated on two floors above a mezzanine floor, and the top storey is almost entirely occupied by a large drawing-office. After H.R.H. The Duke of Edinburgh had declared the new building open, the thanks of the University were expressed by Professor A. F. Burstall, D.Sc., M.I.Mech.E.

Mersey Docks and Harbour Board

In his annual statement, given last week, to the Mersey Docks and Harbour Board, the chairman, Colonel J. G. B. Beazley, said that there was an increase in traffic through the docks, but the financial returns did not equal those of the previous year. The largest factor affecting the situation was the increased operational costs due to increased charges for labour and materials, and the incidence of certain major repair items. In spite of this, he continued, the board was able to reduce the deficit remaining from the immediate post-war period and to allocate a certain sum to the depreciation and renewals fund. To meet the higher costs it had been necessary to increase harbour dues and these new rates, the chairman stated, had been accepted by those using the port. Colonel Beazley mentioned that the tonnage of goods handled showed a considerable increase, particularly the foreign export traffic, and commented upon the wide variations in the amounts of various commodities and also the reorientation of trade. The major problem was storage space, which still remained acute in spite of the extensive rebuilding of transit sheds; however, the reconstruction programme to make good war damage to sheds continued to make progress. During recent years a large number of modern cranes had been put into service; but, the chairman stated, the difficulties in providing space for ships and goods were increased by bulk buying, which resulted in particular cargoes passing through the port in gluts.

Incentive Schemes in Building and Civil Engineering

In June last, all main contractors in England, Scotland and Wales on building sites with contract values over £1000 in the case of new work and £2000 in the case of maintenance and repair work were asked by the Ministry of Works how many of their operatives were paid under an incentive scheme of bonus payments related to output or targets. The survey did not include sub-contractors' men or local authorities' direct labour. This week, the Ministry of Works has stated that returns were received from 31,564 sites on which work was proceeding at the time, representing about 60 per cent of the total sites to which the inquiry forms were sent. These returns, which covered 347,319 operatives, revealed that in England and Wales 28 per cent of the sites possessed incentive schemes for 41 per cent of the main contractors' labour. In Scotland incentives have been adopted more recently, and there the survey showed that there were incentive schemes on 11 per cent of the sites, covering 12 per cent of the labour force. On housing work as a whole, in England and Wales, incentive schemes were operated on 31 per cent of the sites and for 44 per cent of the men. On housing sites, with a contracts value greater than £10,000—on which two-thirds of the housing labour force was employed—the proportion of sites operating incentive schemes was 49 per cent, covering 53 per cent of the operatives. Of the sites engaged on maintenance and repair work 24 per cent claimed to be operating incentive schemes based on output, covering 26 per cent of the total labour force engaged on this work. The Ministry's report on the survey, which is published by H.M. Stationery Office, includes a series of tables indicating that in England and Wales the incentive schemes operating in June showed great similarity.

Merger of Motor Companies

It was announced on Friday, November 23rd, that Morris Motors, Ltd., and the Austin Motor Company propose to form a holding company with an authorised capital of £5 million, having as its chairman Lord Nuffield, with Mr. L. P. Lord acting as deputy chairman and managing director. Subject to Treasury consent, the holding company will make an offer to the ordinary stock and shareholders of the two companies to exchange its existing 5s. stock units for an equivalent number of 5s. ordinary shares in the holding company. The boards of these separate organisations have for some time been considering such an amalgamation, in view of the increased competition from similar organisations, both at home and abroad. In a joint statement by the chairmen it was concluded that unified control would not only lead to more efficient and economic production, but would further the export drive and be beneficial to manufacture and assembly abroad.

Metropolitan Water Board

The annual report of the Metropolitan Water Board for the year ended March 31, 1951, has just been published. During that year the board supplied a total of 116,712·4 million gallons of water, of which nearly 2500 million gallons was supplied in bulk to adjacent undertakings. These figures correspond to an average daily consumption of nearly 320 million gallons in total, or 313 million gallons in the board's direct area of supply. The usual high standard of purity of the supply was maintained during the year; of 11,210 samples of water being pumped into supply from filtration stations and wells, 99·8 per cent contained no *bact. coli* in 100 ml. The report contains some interesting explanations of the problems which the board had to face during the year, one of the more important of which was the question of the supply from the River Lee, which at present yields about one-sixth of the total requirements. Considerable development is taking place in the Lee Valley, the new towns of Stevenage, Harlow, Hatfield and Welwyn all being situated within the catchment. The board decided in 1946 "that every endeavour should be made to prevent any additional discharge of sewage effluent into the river or its tributaries, above the board's intakes, and the further abstraction of water from the underground reservoir in the chalk which supplies pure water to the river or its tributaries." One of the methods suggested for draining the new towns was, therefore, that of taking some 12 million gallons daily of sewage effluent in an outfall pipe for about 12 miles to below the Board's intake at Chingford. It was subsequently suggested that the cost of this main might be saved by constructing a disposal works at Rye Meads, the effluent being disposed of in a large area of sandy gravel which exists there, and this proposal has been adopted. The report also contains notes on the possibility of the spread of poliomyelitis (infantile paralysis) by public water supplies, and on the detection and suppression of waste of water.

The End of an Era

By EDWARD H. LIVESAY

No. III—*(Continued from page 644, November 23rd)*

THE chief objective of the journey from Vancouver was to become acquainted with the "T1" class of engine. Therfore, having reached Revelstoke and seen "The Dominion" taken over by two of those engines, it will be as well to examine them in detail before continuing towards Calgary.

"T1" Class Locomotive

In 1929 twenty 2–10–4 "Selkirk" type locomotives, designated Class "T1a," were built by the C.P.R. specially for passenger and freight service between Revelstoke and Calgary; they were reputed to be the heaviest and most powerful locomotives in the British Empire.* Numbered 5900/5919, they gave and are still giving good service: No. 5905 (Fig. 8, page 643, Nov. 23rd issue) is seen on which are the subject of the present articles, but the steam pressure was 275 lb, or 10 lb less; the cylinders were 25½in, ½in larger; a dome was fitted, "alligator" crossheads, and there were certain minor variations in the heating surface figures. No attempt was made, as in the later engines, to clean up the lines, but they were fine, impressive engines; incidentally, I first became acquainted with the class through No. 5904, as was described in The Engineer in 1939. In that year ten more of the class, 5920/29 "T1b" were built by the Montreal Locomotive Works—who were responsible for them all—in which certain modifications were embodied and in 1949 a final six were turned out, Nos. 5930/35, "T1c," 5935, bearing the regrettable distinction of being the last steam locomotive to be built by or for the C.P.R., marking "the end of an era," and it is with the "T1b" and "T1c" engines these articles are chiefly concerned. Their particulars are given in the next column.

Canadian Pacific Railway, Mechanical Department.—Counterbalance Record

Balanced at Montreal Locomotive Works; date, January 29, 1949. Engine No. 5930, Class T1c (5930–5935)

Item No.	Weights of main rods	Right hand	Left hand
		lb	lb
1	Weight of little end	417	416
2	Weight of big end	787	787
3	Weight, total	1204	1203
	Reciprocating weights		
4	Piston and rod, complete: piston head, 248 lb; piston ring, 90 lb; piston-rod, 409 lb; piston nut, 24 lb	771	—
5	Crosshead, 658 lb; wrist pin, nut and washer, 96 lb; and key, 17 lb, complete	771	—
6	Union link	32½	—
7	Little end of main rod	417	—
8	13 per cent big end of main rod	102	—
9	Weight of reciprocating parts, total	2093	—

Rotating weights

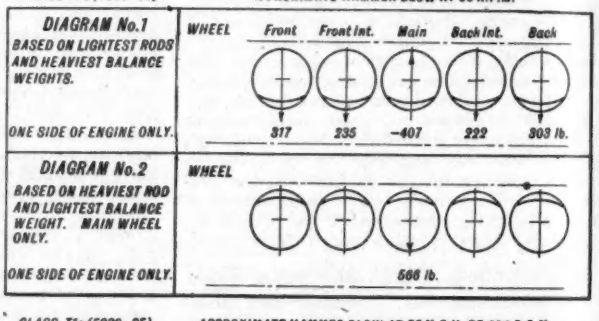
		Front		Inter-mediate		Main		Back intermed.		Back	
		R	L	R	L	R	L	R	L	R	L
		lb	lb	lb	lb	lb	lb	lb	lb	lb	lb
12	Eccentric arm (equivalent weight at crank pin)	—	—	—	—	90	90	—	—	—	—
13	87 per cent big end main rod	—	—	—	—	675	675	—	—	—	—
14	Side rods	153	152	494	498	750½	747	554½	553	153	152
15	Crosscounter balance allowance	—	—	—	—	330	330	—	—	—	—
16	Weight, total	—	—	—	—	1845	1842	—	—	—	—
	Recip. weights to be balanced on each wheel:										
17	Minimum	200	200	200	200	—	—	200	200	200	200
	Weights required to be hung on pins										
19	Minimum	353	352	694	698	—	—	754	753	353	352
20	Maximum	350–360		690–700		—	—	750–760		350–360	
21	Actual (engine turned out)	360	353	700	700	1541	1521	750	750	357	357

The "T1b/c" classes are built for somewhat higher speeds than the "T1a"—though perhaps this should read "they reach higher speeds with less objection," as they all do the same speeds down from Stephen to Calgary, whether built for it or not! To this end some weight has been taken out of the motion—Dean single-bar crossheads are used, for instance, and great attention has been paid to the balancing. The effect of all this is evident when one rides the two classes at 55/60 m.p.h.; the "T1a" class is very rough riding, with the heavy motion obtrusively in action, whereas the "T1b/c" classes are—well, not quite so rough! Neither is exactly diesel-electric. In this connection the weights of reciprocating and revolving parts and the figures of hammer-blow very kindly supplied by Mr. Leo George, Assistant Superintendent of Motive Power, C.P.R., are most interesting and well repay study. I have now ridden several thousand miles on these fine engines and have always been an admirer of them and their work, but I have never been able to forget that after all, though they frequently run at express speeds—have to, in fact, to keep their schedule—they are not really suitable for anything much over 45 m.p.h., being actually freight engines. When running down from Stephen to Calgary at 55/60 m.p.h., round a great deal of quite sharp curvature, not all the careful balancing and cross-balancing in the world, coupled with side-play allowed the first coupled axle, can conceal the fact that one is on a ten-coupled locomotive weighing 327 tons, travelling faster than a freight engine should be expected to! I confess I was very unhappy the first time I was rushed over this stretch on No. 5904, felt the impact of the huge engine hitting bends at speed

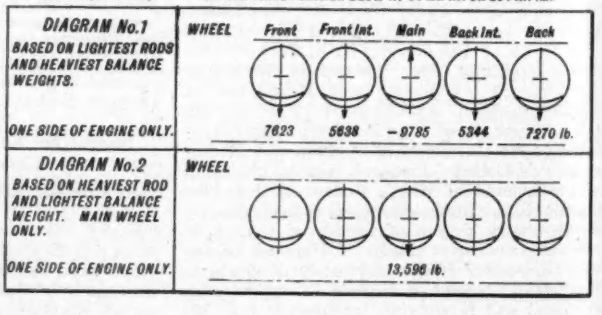
Main Particulars of T1b and T1c Engines

Cylinders	25in by 32in
Driving wheels	63in
Tractive effort without booster	76,900 lb
Tractive effort with booster	89,400 lb
Weight, leading truck	16 tons
Weight, drivers	138 tons
Weight, trailing truck:	
First axle	19 tons
Second axle	25½ tons
Weight, engine, light	181 tons
Weight, engine-loaded	200 tons
Weight, tender, light	55½ tons
Weight, tender, loaded	127 tons
Tender capacity, oil	4,000 Imperial galls
Tender capacity, water	12,000 Imperial galls
Firebox	140in by 96in
Grate area	93·5 square feet
Tubes	Seventy-two 2¼in
Flues	196 3½in
Length	20ft 10⅞in
Heating surface:	
Tubes and flues	4,642 square feet
Firebox	367 square feet
Arch tubes	45 square feet
Total fire	5,050 square feet
Superheat	2,032 square feet
Combined	7,086 square feet
Steam pressure	285 lb
Factor of adhesion	4·05

CLASS T1c (5930-35) APPROXIMATE HAMMER BLOW AT 60 R.P.M.



CLASS T1c (5930-35) APPROXIMATE HAMMER BLOW AT 55 M.P.H. OR 294 R.P.M.



the turntable at Field, with the Kicking Horse River, here wide and shallow, ceaselessly murmuring over its rocky bed in the background. These twenty engines are very similar in general lay-out to their successors,

*The Canadian National Railway makes the same claim for its five "T2" class 2–10–2 locomotives, which I described in The Engineer, March 3, 1944. They have cylinders 29in by 32in, drivers 57in, T.E. with booster 91,735 lb, boiler exceptionally large, 8ft. 8in diameter, tube length 21ft 6in, grate area 80·3 square feet. Pressure 200 lb. Coal-firing.

Both the C.P.R. "T1" and the C.N.R. "T2" classes are impressive engines, but not so remarkable, perhaps, as the wonderful "GL" 4–8–2+2–8–4 "Garratts" on the South African Railways, with their 89,130 lb T.E. and only 214 tons weight on a gauge of 3ft. 6in. I can think of no possible reason why the "Garratt" should not have done splendid work in the Rockies if only it had been tried there; the environment should have suited it admirably.

and pictured what was probably happening to the track due to the leviathan with its 46ft. wheelbase forcing its way round them. Granted, it always got round, but I don't know why! Though I have made this same trip several times since, I am still not perfectly at ease when doing it. It is under such conditions that a diesel-electric multiple-unit machine scores so heavily, in the perfection with which it adapts itself to the track, without blow or wrench.

To sum up, the engines Nos. 5920/35 are a considerable improvement on the earlier class when employed on passenger service and when their day on this sort of train is done and they are relegated to freight work east of Calgary, which I understand is to be their fate, after all they will only be doing the work for which their design pre-eminently fits them—at last they will be 100 per cent round pegs in circular holes.

The semi-streamlining of these engines gives them a very neat and pleasing appearance and is similar to that of the 2850 "Royal" Hudsons. The classification lamps are "air-smoothed," and the head light is recessed in the smokebox door. The cab-sides are sloped inwards, presumably to make it easier for the enginemen to sit looking ahead through the side windows, the front windows being perforce so diminutive that they give only a very small field of vision; nine-tenths of the observation is done from the former. Cylinders and frames are cast integrally and the tenders have Commonwealth cast steel waterbottom underframes. All wheels have plain bearings (the dimensions are given on the outline drawing), and both leading and trailing trucks are capable of taking 18 deg. curves. The leading coupled axle has an allowance of 1in sideplay each side of the centre-line and the wheels are flange-lubricated.

The boiler, nickel-steel, is 8ft 0½in o.d. at the third course, tapering to 7ft 0½in at the front. Sheet thicknesses are: smokebox ½in; front tubeplate ⅝in; first ring $\frac{13}{16}$in; second $\frac{15}{16}$in; throat, outside, ⅞in, inside $\frac{9}{16}$in; back tubeplate ½in, wrapper $\frac{7}{16}$in; crown $\frac{13}{32}$in; firebox sides ⅜in; backhead $\frac{9}{16}$in; combustion chamber ⅜in. There are three 3in safety valves. On the left side is an Elesco feed-water heater and pump and on the right side, below the cab floor (Fig. 15) a Hancock 7500 gallon injector. The superheater (type E), is by the Superheater Company, who also supply the multiple throttle. The superheated turret is outside the cab, in front, jacketed, the saturated steam turret being inside the cab. The former supplies steam to the feed-water pump, air compressor, blower, booster, oil atomiser (burner) and pump suction heater; the latter supplies the steam heat line, injector, dynamo, lubricator, and rail-washer, which directs jets of steam on to the rails ahead of No. 1 drivers and behind the trailing truck wheels. Steam for the whistle is taken through a 3in control valve from the steam line at the smokebox. The saturated steam turret has a stop valve outside the cab.

The side-rods are of high-tensile nickel-molybdenum steel, and all pins except the front and back have floating bushings. The Walschaert valve gear has 7in travel, the valves being 14in diameter; lap is 1⅛in, lead $\frac{5}{16}$in and exhaust clearance ⅛in. The valve chest and cylinder bushings are cast iron. Crossheads are of the Dean single-bar design. The reverse gear is air-operated, (Fig. 15) the motor being in the cab. Two 8½in cross-compound air-compressors are mounted on the right side of the engine, the water pump on the left. Westinghouse brakes are employed, (eight E-T type), with a pedestal type brake valve and No. 8A distributing valve; the main reservoirs of 80,000 cubic inch capacity, are cast in the frames. All wheels except the leading truck pair are braked; the tender wheels are clasp braked.

The firebox is bricklined, fitted with a bootleg an adjustable damper, controlled by the fireman by the lower of the two horizontal handles seen in Fig. 16; the upper regulates the oil supply. The foundation ring is a one-piece steel casting, 3½in thick. Neverclog sanders with Globe valves are fitted and the sandbox is of large capacity, 30/40 cubic feet, supplying four lines, two each to the second and main drivers. A Detroit force-feed lubricator, driven from the combination lever of the Walschaert gear, with a drifting attachment, serves eight feeds; it is of twenty-four pint capacity with thermostatic control. Two feeds go to the cylinders, two to valves, one to the water pump, one to air compressor, one with a four-way fitting to the guide-bars, and one spare. An Alemite grease system is applied to the spring and brake gear and some of the motion, and a hydrostatic lubricator for the booster is mounted in the cab. The oil burner is a 3½in Von Boden, with C.P.R. control valve in the cab (this system was described in THE ENGINEER, November 24, 1950).

These locomotives are fitted with a snow-plough for winter use, and the front cab windows have an arrangement for directing air jets against them to prevent frosting over. Other items of equipment comprise Franklin booster, an air whistle operating device, Flannery flexible stay bolts with tell-tale holes, Pyle-National headlight and electric lighting throughout engine and cab. The latest engines of this class have Sorbo rubber seats, which are exceptionally comfort-

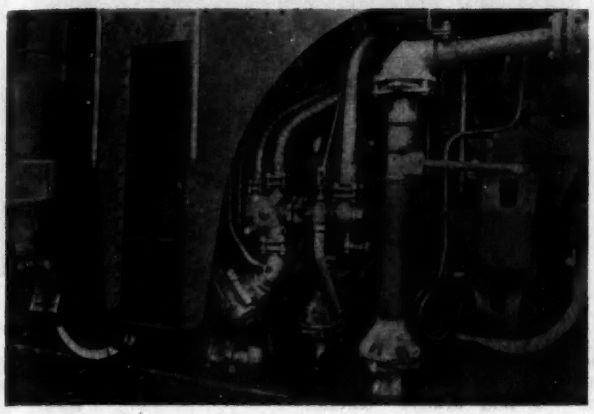


FIG. 12—INJECTOR AND STEAM PIPE TO BOOSTER

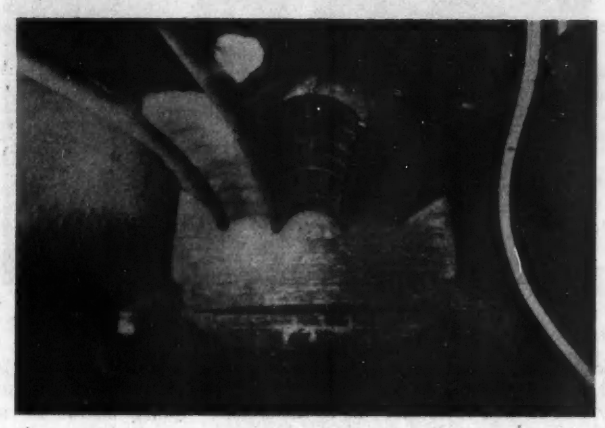


FIG. 13—BRICK ARCH AND ARCH TUBES, "T1C" LOCOMOTIVE

FIG. 14—DOUBLE-HEADER PASSENGER TRAIN LEAVING UPPER SPIRAL

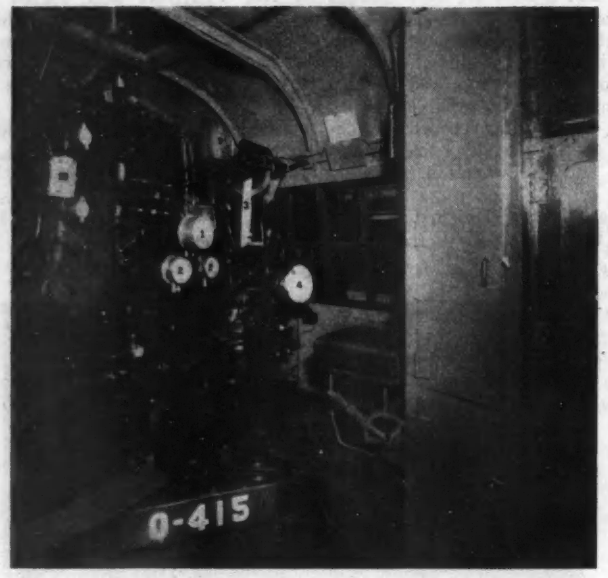


FIG. 15—DRIVER'S SIDE OF CAB

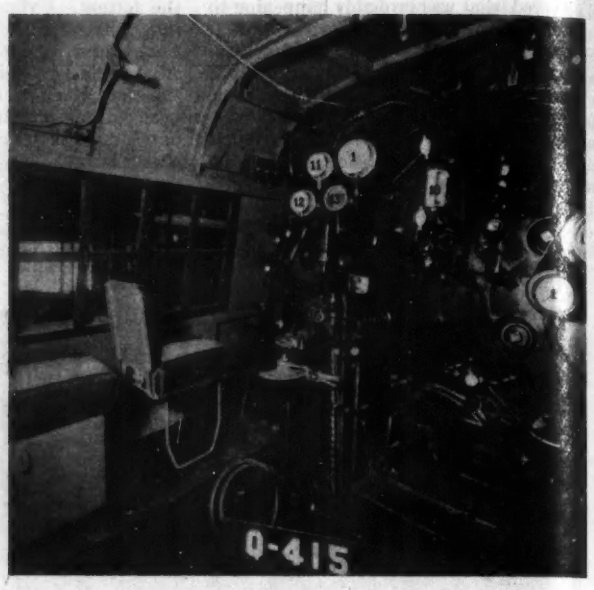


FIG. 16—FIREMAN'S SIDE OF CAB

able. From the drawing inset between pages 702 and 703, what is at first sight a double chimney will be seen to consist—as to the second half—of a receptacle into which the hood (turned up over the actual chimney when passing through a tunnel, to direct the waste gases backwards), can be swung. A very neat way of disposing of it, proving that on these engines æsthetics have been considered as well as mechanics, and the two things combined.

FIG. 17—THE EASTBOUND "DOMINION" ENTERING LAKE LOUISE

Figs. 15 and 16 show the driver's and fireman's sides of the cab and the chief controls they are individually concerned with: (1) steam pressure, (2) air pressure, engine and train pipe, (3) throttle, (4) reverse, air operated, (5) injector, outside under cab floor, (6) oil fuel indicator, tender tank, in feet, (7) brake valves, (8) sand door for flue scouring, (9) surface scum blowdown indicator, (10) water gauge, electrically lit, (11) steam heat, (12) booster, (13) feed pump, (14) oil fuel handle, (15) damper handle, (16) various firing system regulators. The good arrangement of the controls will be noticed; except for the fireman to feed sand through the firebox, it is rarely necessary for either engineman to leave his seat—the sandbox is in the front of the tender. The roominess of the cab is another advantage; it is 10ft wide overall and at least 8ft long; the spare seat, with locker beneath, behind the fireman's, is prominent, while behind the driver's seat will be seen a large clothes locker. Between the throttle lever and the steam gauge there is a notice worded: "Do not shut the throttle until the speed has fallen below 40 m.p.h." I had always assumed this order was to offset the effect of the heavy motion being suddenly deprived of cushioning at speed but, on asking one of the engineers about this, he questioned my surmise, saying the shutting of the throttle upset cylinder lubrication. This seemed to me to be a minor matter, and to clear up the point Mr. Leo George, the assistant superintendent of motive power, was asked for a ruling. His reply reads: "Your interpretation of the notice . . . is correct; we do not wish the throttles to be closed completely at high speeds on account of the difficulty in balancing these engines, which will develop on down grades if the engineer is not careful."

The cab is of the vestibule type; that is, completely closed in at the back and with side doors that shut snugly; there are two ventilating shutters in the roof. The tender carries 12,000 Imperial gallons of water and 4100 Imperial gallons of oil; it weighs 127 tons loaded. In passing, the floor of the cab is approximately 7ft from rail level.

REVELSTOKE TO CALGARY

Last week's article found us not only at Revelstoke, but a little way up the gradient out of that town, and now, having described the "T1" class in detail, it will be in order to take up the work they do and the environment in which it is done. The C.P.R. main line through the mountains includes two superlatively difficult sections, one being the 40 miles from Revelstoke to Glacier up the west side of the Selkirks, and the other following the twists and turns of the Kicking Horse River from Golden to Stephen, at the summit of the Rockies. The profile, reproduced in Fig. 19, shows clearly the heavy locomotive work these two stretches exact: but they must be covered in the cab of one of the pair of engines—or trio, it may be—needed to lift a 1300-ton train up and over the mountains before the observer can fully realise the magnitude of the task involved. The line follows the convolutions of the Illecillewaet River out of Revelstoke all the way to the summit of the Selkirks at Glacier, crossing the stream ten times and

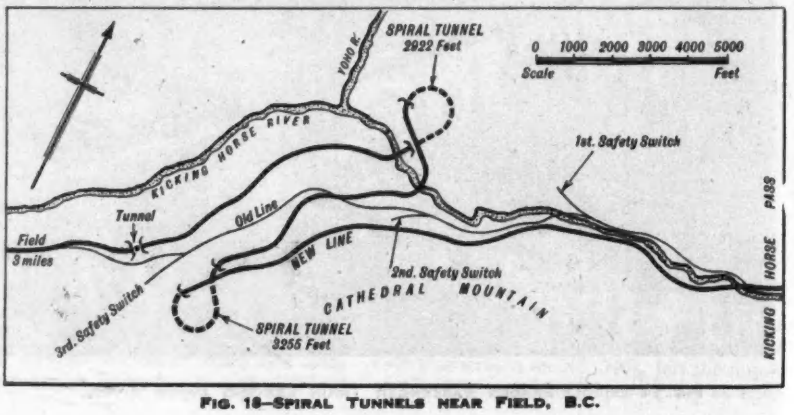


FIG. 18—SPIRAL TUNNELS NEAR FIELD, B.C.

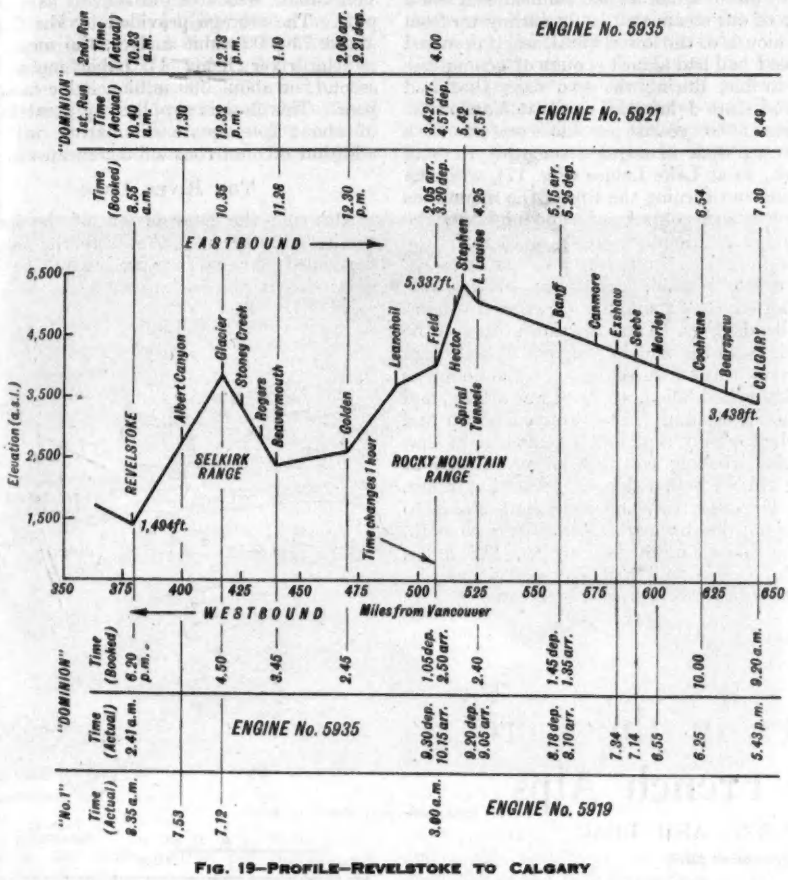


FIG. 19—PROFILE—REVELSTOKE TO CALGARY

climbing 2284ft. Things were even worse in the early days, before the Connaught tunnel cut out the zigzag and the Rogers Pass length, with its miles of snowsheds admittedly giving some protection from avalanches that so often crashed down on the track, but which could not eliminate all the hazards resulting from the tremendous western Selkirk snowfall. A little of the Illecillewaet's energy is harnessed in Box Canyon to provide Revelstoke with power and light, and farther up one or two lengthy snowsheds and brief tunnels show that the Connaught did not cancel out all operational risks nor conceal all the old constructional difficulties. Traces of the old zigzag can still be seen high up on the flanks of the range—here a cutting, there an embankment or the piers of a vanished bridge, reminders of the days when three or four small engines struggled up the bank with half a dozen cars, as I well remember before the 1914-18 War. No. 5921 and the "pusher" were in no way stressed on this occasion, each handling 650 tons; the permissible load of the "T1" class in the mountains is 700 tons. The speed was in the neighbourhood of 25 m.p.h on a gradient much of which was 2 per cent, giving ample opportunity to enjoy the panorama of snow-clad peaks, glaciers, cliffs and canyons The line is closely hemmed in by wooded slopes and jagged cliffs, between which the Illecillewaet foams down to the Columbia. On this heavy gradient the opportunity is always taken to pass sand through the flues when the throttle is well open, and one notices that the exhaust immediately turns dark and soot rains down on to the snow, clear evidence of the scouring effect.

At Glacier, 12.32 p.m., the pusher came off, and "The Dominion" entered the 5-mile double-track Connaught tunnel; it was traversed in about ten minutes—there is a speed restriction of 30 m.p.h. through it. From west to east the gradient falls at 1 in 100, and the train uses the left-hand metals to give the engineer a better view of possible rockfalls from the roof. It is very well ventilated, the air having been quite fresh on every occasion when I have been through, but it has been said that the bore can become very sulphurous when there is heavy traffic, despite the diesel-driven fans and the 21½ft by 29ft cross section. Beavermouth brought a stop for water, after which there came an uninterrupted run of 28 miles along the Columbia River valley to Golden, with the speed up to 45 m.p.h. or more, and here another pusher came on, of much older vintage, helping "The Dominion" up to Leanchoil, the Kicking Horse River boiling alongside all the way. It was not so turbulent as the Illecillewaet, and was mostly icebound, its bed in places so narrow, with part taken to make a footing for the railway, first on one side and then on the other, that it is not a matter for surprise that at times ice-jams form, which can raise the water level over the rails. Field was reached at 3.42, so a few minutes had been picked up since leaving Revelstoke, but no real effort is made to do this over these difficult stretches of line, where maximum speeds are rigidly enforced in the interest of safety. The average inclusive speed from Revelstoke had been 25 m.p.h., and there had been six or seven stops.

Field is a divisional point, and purely a railway town, where the crews change and engines and cars are serviced. You also set your watch an hour ahead—going east—from Pacific to Mountain time. Here the assistant superintendent, Mr. Lewthwaite, introduced himself, having been advised from Vancouver of my coming and its purpose, and it is safe to say that from this moment, for three days, my way was made smooth in so far as this was possible in a land of belated winter, snowslides and blizzards, which kept disrupting things as fast as they were arranged. I felt at once that though Nature was not on my side, Mr. Lewthwaite was, and the balance was in my favour. Duly replenished, "The Dominion" pulled out at 4.57 p.m. with Engineer Kirk, Fireman Watt, Assistant Superintendent Lewthwaite, and myself in the cab of No. 5921, the last mentioned individual feeling duly honoured, but somewhat embarrassed at finding himself in Engineer Kirk's seat, at the latter's invitation, fully realising what a poor substitute he was for the rightful occupant. He hastens to assure the reader he did *not* drive No. 5921, nor make any attempt to do so; Kirk was still in control and doing everything necessary, which was not very much, as the greater part of the responsibility for our safe and continued progress upward through the Spiral tunnels to the

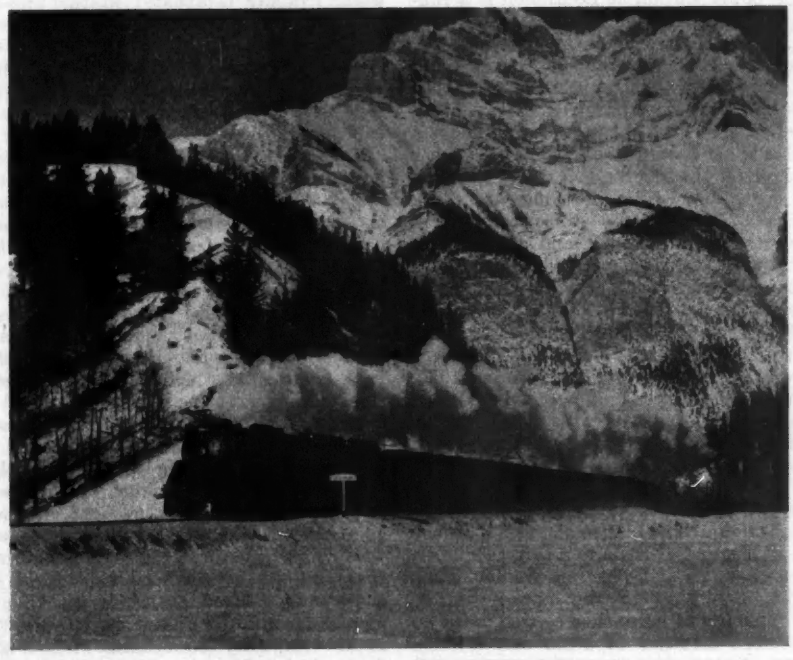


FIG. 20—AT SPEED, EAST OF BANFF

Great Divide devolved upon the crews of the two "pushers," Nos. 5803 and 5811, that put No. 5921 into a very inferior position of mere "train engine." Until this dawned on me I was quite shocked at Kirk for putting me, a humble observer, in the seat of the mighty—what could he be thinking of? And with the assistant superintendent in the cab to see him do it! Reassured on this point, Kirk pointed out to me a cable conveyor crossing the track from a newly-opened mine in Mount Stephen to a concentrator by the lineside, said to be working day and night on "base metals." Then came the Spiral tunnels, (Figs. 14 and 18), and in them once more I enjoyed an exposition of Dante's Inferno: a dive into thunderous blackness, a sense of sulphurous suffocation, 140 deg. more or less of heat, breathing through a wad of cotton waste the while, and so on, the excursion being even worse than usual because there were three engines this time, all digging their toes in and blasting away with wide throttles on the 2 per cent gradient. This is another locomotive experience that has to be undergone to be appreciated to the full. Ultimately emerging from the upper spiral, I looked back into the great valley out of which we had climbed, and saw a wisp of our steam still lazily curling up from the mouth of the lower spiral, and it occurred to me I had had almost enough of locomotives for awhile, during the two days that had passed since I left the coast at Vancouver. I began to yearn for the comfort of a reclining chair in a quiet, smoothly running coach, so at Lake Louise (Fig. 17), with the setting sun turning the tips of the mountains to pink and gold, I said goodnight to the courteous, friendly crew, and with the Superintendent retired to the coach, there to remain, discussing Shakespeare while the "Dominion" swirled round the bends (Figs. 19 and 20), down through the foothills to a stand in Calgary at 8.49 p.m. I do not think I missed much by so doing, as darkness had fallen, my head was aching, and I should certainly have dropped asleep and pitched off my seat had I remained in that roaring, rocking cab any longer. No. 5921 had ridden well, and I was pleased with her, but I craved rest, and something stable to sit upon; the coach and Calgary gave me both. From Lake Louise to Calgary, 117 miles, "The Dominion" had averaged 40 m.p.h., quite enough for a freight locomotive.

(To be continued)

Hydro-Electric Power in the Isere Catchment of the French Alps

No. II—THE RIVERS BOURNE AND DRAC

(Continued from page 649, November 23rd)

PROCEEDING upstream from the power stations described in Part I, there are three sites of future low heads plants on the Isere itself at St. Hilaire, Beauvoir and Armieux (see Fig. 1). There is also a project envisaged on the Furon (Sassenage) and several developments on the River Bourne. The Bourne is a fairly small tributary, which runs for the greater part of its length in a precipitous gorge, mainly in limestone formations, draining the Vercors massif. The route from Valence to Grenoble by le Villard de Lans follows the river valley for a large part of its length.

The power station at Bournillon is a run-of-river installation built beside the Bourne (Fig. 1), with two intakes higher up the river, one giving a head of about 100m and supplying a Francis turbine set of about 5000 h.p., and the other driving two Pelton wheel sets, each of about 7000 h.p. under a head of about 300m. The installations higher up the river (La Bourne and Goule Blanche) are small run-of-river developments. The left bank tributary Le Bournillon, which runs partly underground and from which the power station mentioned above takes its name, is at present being studied with a view to power production.

The scheme of main interest on the Bourne, however, is the project of Pont-en-Royans, which was completed during 1950. An arch dam has been built across the Bourne, thus forming a reservoir with an impounded level of 305 N.G.F.,* which is slightly below that of the tail-race of the Bournillon station. The dam and temporary works are shown in plan in Fig. 7, which also shows the intake works of the tunnel. This tunnel is nearly 6km in length and leads to a surge chamber, valve chamber and pipe-line leading down the mountainside to the power station. The tunnel is of horse-shoe section, with an equivalent diameter of 3·6m and is lined with concrete. The tail-race leads from the power station into the Bourne, the Vernaison River, a tributary which flows into the Bourne at that point, being diverted to accommodate it.

The annual power production of the scheme is about 100 million units, which is obtained from two horizontal Francis turbine sets generating at 11kV and each of 11MW capacity. The turbines are of the type first installed at the power station of Peage-de-Vizille, which is described in Part III, and each has a double runner. A relief valve is provided for each machine, so that excessive water hammer is avoided in the pipe-line when the turbine is stopped, by allowing the flow to discharge into the tail-race at a gradually diminishing rate. The maximum head on the machines is about 110m (tail-race level 196m) and the normal flow 24 cubic metres per second.

The dam is of arched design, being 24m high above the stream-bed level. It is rectangular in cross section with a thickness of 3·4m throughout and with a lip overhanging the downstream edge by 0·7m along the spillway section, which covers the greater part of the crest of the dam, as shown in Fig. 7 and also Fig. 9. Substantial abutments were constructed. There was a fault in the neighbourhood of the right bank abutment, which necessitated extensive pressure grouting in the footing of the dam near the right bank. It was necessary to form a grillage of grout tubes around the location of the fault and grout them thoroughly and then to grout on the line of the dam itself. The sketch, Fig. 8, shows the construction of the right bank abutment, which was laid out in the manner shown to avoid an accumulation of water, with the consequent hydrostatic force, on the upstream face of the abutment. The lay-out of the temporary works is shown in Fig. 7, from which it may be noted that the diversion tunnel was afterwards used as a scour pipe. The storage provided by the dam is about 730,000 cubic metres, the mean flow of the river being 17 cubic metres per second, or about 536 million cubic metres a year. This flow is supplied by a catchment of about 250 square kilometres, with the addition of numerous subterranean streams.

* N.G.F.—Nivellation General Français.

The River Drac

Although the Drac is one of the largest of the tributaries of the Isere, it was not developed for power production to any great extent above the confluence with the Romanche until the construction of the projects of Le Sautet and Cordeac. A difficulty which retarded development was the existence of an old river bed, which would have caused substantial seepage at the various reservoir sites which were first considered.

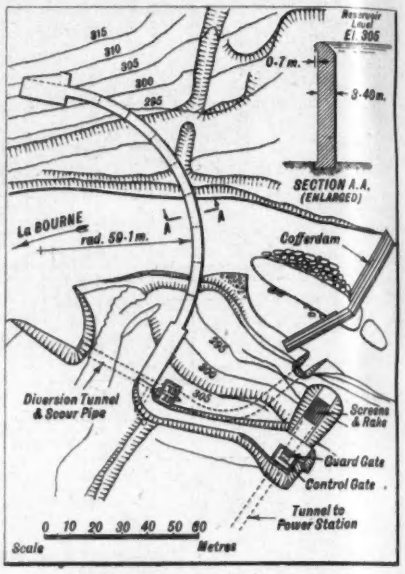


FIG. 7—PONT-EN-ROYANS DAM

The dam and power station of Le Sautet were constructed between 1931 and 1935, and work on the Cordeac project was commenced in 1941 and carried out largely in the war years. The two schemes were, however, designed to operate in conjunction with each other, there being no intermediate storage between the two. Access to these two schemes involved substantial subsidiary works, the route nationale 85, better known as the Napoleon Road, being the only highway along the valley.

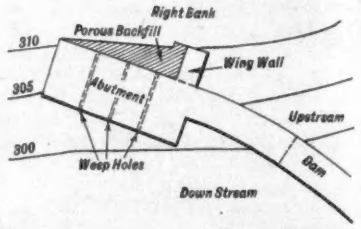


FIG. 8—SKETCH OF RIGHT BANK ABUTMENT

The dam and power station of Le Sautet are shown in Fig. 10, from which it may be seen that the Cordeac power station is supplied directly from the tail-race, a small weir being constructed downstream of the Le Sautet power station to form the forebay of the Cordeac tunnel.

The power station is built in the rock at the bottom of the gorge, which has practically vertical faces at this point, and was thus excavated on either side to accommodate it.

There are six horizontal 13MW alternators in the power station, each driven by two Francis turbines. It is a peak load station, producing about 150 million kWh annually, the head varying between 93·5m and 53·5m and the maximum flow which can be utilised being about 90 cubic metres per second. The mean annual flow of the Drac at this point is 34 cubic metres per second. A flow of 2000 cubic metres per second can be passed by the spillways in the event of an exceptionally large flood. Access to the power station is by a lift, replacements of machinery being handled by a cableway.

FIG. 9—PONT-EN-ROYANS DAM

The dam is a gravity structure curved in plan, and is 126m high and about 80m across at the crest. At first glance it would appear that the site was ideal for the construction of an arched dam, and in fact the first design of the project envisaged this type, but subsequent investigations revealed that a gravity design was better suited to the rock conditions of the gorge. Within the body of the dam are two valves, each consisting of two butterfly valves, in series, which can be adjusted to discharge sufficient water for the operation of the Cordeac power station, should the machines at Le Sautet be out of service. The jets from the two valves collide, so that the energy of the discharge is entirely dissipated in a length of 35m within the thickness of the dam. The reservoir formed by the dam has a capacity of 130 million cubic metres, of which 100 million cubic metres are above the bottom level of the power station intake at 725 N.G.F. It is supplied by a catchment of 990 square kilometres. The large volume of storage was not necessary for the operation of the plant, a high dam being constructed to provide a high head rather than a large storage. The reservoir is forked and extends 7½km up the Drac from the site of the dam, and 5km up the left bank tributary La Souloise.

The tunnel to Cordeac power station has been driven from Le Sautet, on the right bank, for a distance of about 1·4km, where there is a pipe-line bridge crossing the Drac, and a further 3·2km of tunnel before the surge chamber and pressure pipe-lines leading to the power station are reached. The gross head is 92·5m and the minimum net head 84·2m, there being two vertical Francis turbine sets, one of 42MW and one of 21MW (total flow 87 cubic metres per second) in the power station, the annual power production being about 220 million units.

The construction of the entire Sautet-Cordeac project was carried out under very difficult conditions. Extensive stabilisation works on the cliff faces were necessary in the Sautet gorge, and pressure grouting was extensively employed to reduce the permeability of the rock formations.

Schemes Under Survey

Three large projects are at present under survey in the Drac valley. Upstream of Le Sautet, a large dam and a power station are envisaged at Pont-du-Loup. The project of St. Pierre-Cognet has been planned in some detail, and will involve the construction of an arched dam about 70m high across the Drac just upstream of the confluence with the River Bonne (see Fig. 1). The reservoir formed by this dam will have a storage capacity of 29 million cubic metres (useful storage 11 million cubic metres), with a top water level of 580 N.G.F., corresponding to the tail-race of the Cordeac power station. As in the case of Le Sautet, the height of the dam was not governed by the amount of storage required in the reservoir; a high dam provided the most economical method of developing the head. The reservoir will also be supplied by an extension of the tunnel feeding the existing power station of Bonne Inferieure, which will thus be replaced by the newer and larger project. The installed capacity of the Bonne Inferieure station is about 6MW.

From the St. Pierre dam a tunnel will be driven through the mountain on the left bank for a distance of 2·5km, where there will be a surge chamber and pressure shaft leading to the underground power station of Cognet, and then a tail-race tunnel some 200m long leading back into the Drac. The power station will contain two vertical Francis turbine sets each of 50MVA, the annual production of power being 270 million kWh. A cross section of the dam is shown in the accompanying illustration (Fig. 11). It is expected that work will be started on the project in 1952.

Downstream of the site of the project of St. Pierre-Cognet, a further large project—Monteynard—is being investigated. The preliminary studies indicate that it will be similar in conception to the projects of St. Pierre Cognet and Sautet-Cordeac; there will be a large reservoir at about the level of the tail-race of the Cognet power station, and a power station with an installed capacity of some 200MVA, producing about 750 million units annually.

Sedimentation Problems

One of the most interesting aspects of the development of the River Drac has been the study of the silting of the reservoirs, and the steps which have been taken to prevent it; this subject was recently discussed at the fourth Congress on Large Dams.† Investigations were started as early as 1927, when the dam of Pont-du-Loup and the small power station associated with it were completed and put into service. The Pont-du-Loup dam has the same top water level as Le Sautet dam, and is therefore submerged when the reservoir is full. The reservoir formed by the Pont-du-Loup dam itself, which is on the Drac above the confluence with La Souloise, is known as the Motty reservoir. When the Pont-du-Loup dam was built the project of Le Sautet was already being investigated, and it was intended to utilise the Motty reservoir for a study of the sedimentation of the river. The power station itself was dismantled in 1934 and was submerged when Le Sautet was completed the following year.

During the period 1928–30 observations were made on the sedimentation of the Motty reservoir, the bottom level being contoured

† Paper No. R50: "Quelques Observations Sur L'Alluvionnement dans Les Reservoirs Français," by Messieurs Remenieras and Braudeau, and Paper No.R52: "Les Evacuateurs de Crues du Barrage de Saint-Pierre en Projet Sur Le Drac," by N. Combe. Fourth Congress on Large Dams, New Delhi, 1951

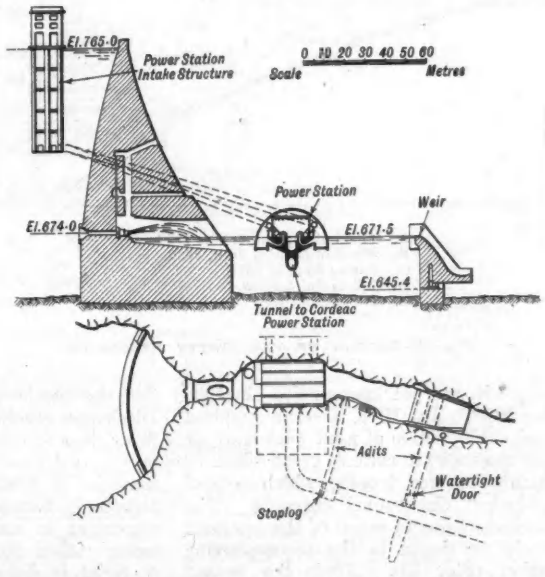


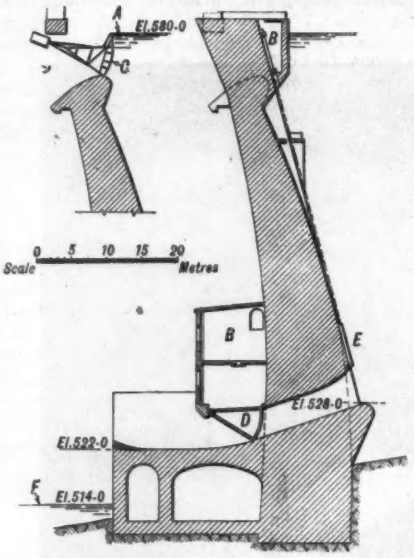
FIG. 10—LE SAUTET DAM AND POWER STATION

at intervals. It so happened that two severe floods occurred in that period (each maintaining a flow in excess of 300 cubic metres per second for a number of hours), making the measurements of particular value. The level of the deposits in the reservoir is shown in the accompanying illustration (Fig. 12); the total volume of material deposited up to August, 1930, was nearly 1,860,000 cubic metres. By the end of 1932, the Motty reservoir had silted up completely, the useful storage capacity having been reduced to about 250,000 cubic metres as against 1,320,000 cubic metres between the levels 757 and 765 N.G.F. when first constructed.

It was decided to empty the reservoir by constructing a tunnel at a level of 742, and with a cross section of 12 square metres, since the original scour pipe was of no further use. The blow-through of the final plug of rock led to a spectacular scouring of the accumulated silt, and a considerable zone of the reservoir close to the dam had been cleared in four days. The upstream parts of the reservoir, however, remained partially clogged after six months of scouring.

A similar silting of the Sautet reservoir has been largely avoided by using the Motty reservoir as a scouring basin. Thus the solid deposits carried down by rolling along the river bed are retained in the Motty reservoir, when the main reservoir is full. When the level of the main reservoir falls to the lower limit of its range, an energetic scouring from Le Motty transports the solid materials to the lower parts of the main reservoir, below the bottom level of the useful storage capacity. This operation must be co-ordinated as much as possible with the requirements of power generation. Experience has shown, however, that the main reservoir must be emptied at intervals since the deposits of finer material carried in suspension by the river accumulate close to the dam and in front of the turbine intakes. It should be noted that emptying is carried out through a scour culvert formed by the former diversion tunnel built for the construction of the dam, which is not shown in our cross section (Fig. 10). This tunnel is 6m in diameter, its intake being about 80m upstream of the dam and the sill level 649 N.G.F.

Le Sautet reservoir has been [emptied twice since it was put into service—in 1938 and in 1948. In 1948, several hundred thousand cubic metres of mud were emptied from the reservoir, in spite of great difficulty due mainly to tree trunks, which several times blocked the tunnel entrance. The various measurements taken of the reservoir bed levels are shown in the accompanying illustration (Fig. 13). After the second emptying, it was apparent that the useful capacity of Le Sautet reservoir down to the level of 725 N.G.F., had been decreased by only 1 or 1·5 million cubic metres due to sedimentation, during the first thirteen years of service. From the various observations made it would appear that the mean annual volume of material carried down by the Drac at Le Sautet (excluding fine material in suspension) is of the order of 250,000 cubic metres. This figure may be compared with the corresponding monthly flow figures given in Part I of this article. It may be noted that Electricité de France has set up a research centre at Le Sautet to study the transport of solid materials by the river.



A. Normal storage level
B. Control room
C. Three sector gates
D. Two sector gates
E. Guard gate
F. Present level of the Drac River

FIG. 11—DESIGN FOR ST. PIERRE DAM

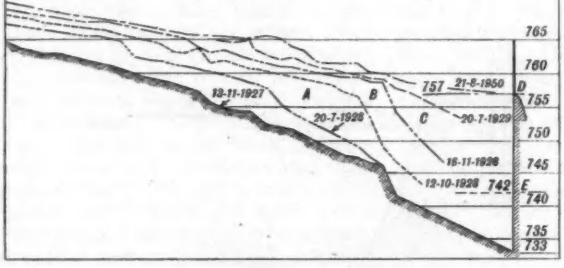
SEDIMENTATION IN THE ST. PIERRE RESERVOIR

In spite of the presence of Le Sautet dam, the problem of silting remains important for the projected dam of Saint Pierre. Discharges of solid material are to be expected from time to time when Le Sautet reservoir is emptied, and a substantial volume of material is brought down by the various tributaries between the two dams, which are torrential in nature. Since the Cordeac tunnel takes most of the river flow, this material is deposited in the main stream, and moved down again only during floods. Another problem is introduced by this behaviour, for the St. Pierre reservoir will extend up to the tail-race of the Cordeac power station so that it will be necessary to avoid the formation of a "bar" of shingle at the head of the reservoir. Reference to Fig. 11 will indicate the steps which have been taken to overcome these difficulties. Normal seasonal floods, consisting of discharges up to 800 cubic metres per second (the normal requirement of the power station is 120 cubic metres per second), will be discharged through the two bottom sector gates marked D, which are of generous dimensions, each being 3m by 4m in area. Exceptionally large floods will also be discharged by three sector gates, each 10m by 6m in area, at the top of the dam marked C. All five gates will handle a flood of 1200 cubic metres per second without an increase of the normal storage level. For very large floods the possibility of a slight increase in the reservoir level has been envisaged.

Scouring downstream of the dam has been studied with hydraulic models, the arrangement adopted being to fan out each of the two jets discharging from the bottom gates which collide before falling on to the stream bed, thus dissipating a large proportion of their energy in the manner of the well-known "ski-jump" spillway. The top gates will only discharge when the bottom gates are already functioning, and a favourable result was achieved by allowing the top discharge to collide with the jets issuing from below. This method does not give complete protection from scour, but was considered to be the most economical solution, because the top spillway will only be used rarely.

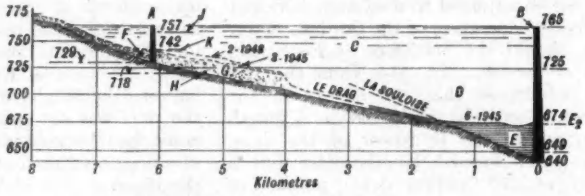
To avoid the deposition of a "bar" near the Cordeac tail-race, it will be necessary to draw down the St. Pierre reservoir to the lower limit of its working range when a flood is expected. In that manner the accumulation of debris which will be brought down by the flood—due to the spillway of Le Sautet as well as the flow of the tributaries themselves—will be transported to the lower parts of the St. Pierre reservoir, or discharged through the bottom sluices. Since the reservoir of St. Pierre is much smaller than Le Sautet with a useful storage of 11 million cubic metres compared with 100 millions, this method will not greatly inconvenience power generation, the storage being made up at the end of the flood. On the occasions when Le Sautet reservoir is emptied, St. Pierre reservoir will also be emptied, and the bottom sluices kept fully open to pass the solid materials downstream.

(To be continued)



A. Flood of September 21st 1928
B. Flood of October 28th, 1928
C. Spring flood of 1929
D. Sill of sluice gates
E. Sill of scour pipe

FIG. 12—SILTING OF THE MOTTY RESERVOIR



A. Pont-du-loup dam
B. Sautet dam
C. Useful storage 100 million cubic metres
D. Dead storage 30 million cubic metres
E. Silt accumulation zone
E_2. Sill of the scour tunnel
F. Profile after flushing of the silt in the Pont-du-loup reservoir
G. Profile of the silt zone
H. Former Pont-du-loup power plant
J. Sill of the sluice gates
K. Sill of the scour tunnel

FIG. 13—LE SAUTET RESERVOIR

Some Fuel and Power Projects*

By H. ROXBEE COX, Ph.D., B.Sc. (Eng.), M.I.Mech.E.†

No. II—(*Continued from page 666, November 23rd*)

Open-Cycle, External Combustion Gas Turbine Locomotive.—I have indicated three methods of preventing the ash in the products of coal combustion damaging the turbine of the open-cycle gas turbine. The remaining and most obvious method is to prevent the products of combustion passing through the turbine. This necessarily means departing from the internal combustion cycles.

The simple open cycle with external combustion is shown in Fig. 10. The combustion air in the furnace is preheated by the turbine exhaust. This would appear to be another cycle capable of using high-ash fuels, and with the additional advantage of simplicity. It seems, in consequence, likely to be suitable for a locomotive which, like many foreign engines, has to use fuel of poor quality. An ability to do the same in Great Britain would be a genuine easement in the problem of coal supply, providing that a real reduction in consumption were achieved, and overall economy were maintained.

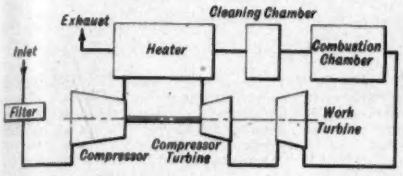


FIG. 10—*Externally Coal-Fired Open-Cycle Gas Turbine for Parsons North British Locomotive*

The conventional piston engine steam locomotive is long lived and low in capital cost, but its average thermal efficiency in operation is only about 5 per cent. Consequently, coal costs figure so highly in a year's intensive duty that a 50 per cent fuel saving would allow about four or five times the present annual expenditure on capital charges. In other words, a coal-burning locomotive giving twice the current average fuel efficiency could be allowed to cost about four or five times as much as the present type.

It seems that such a capital cost figure is likely to be achieved with an open-cycle, external combustion coal-burning gas turbine with direct drive, and the Ministry of Fuel and Power, after consultation with the Railway Executive, has ordered from C. A. Parsons and Co., Ltd., and the North British Locomotive Company, Ltd., a locomotive of this kind giving 1600 h.p. at the rail. The former company are making the gas turbine and the latter company the chassis. The thermal efficiency of this engine is expected to be 10 per cent at one-tenth load, 16 per cent at half-load, and 19 per cent at full load. Calculations of fuel consumption for the Glasgow–London run indicate that it should be about half that of the conventional steam locomotive. A general arrangement is shown in Fig. 11 and the leading particulars are:

Power at turbine shaft	1,800 h.p.
Maximum rail horsepower	1,600
Wheel base	C_0–C_0 (0–6–6–0)
Gauge	4ft. 8½in
Length over buffer beams, ...	64ft 6in
Length overall, ...	68ft 6in
Maximum width	8ft 8in
Maximum height	13ft
Wheel diameter	4ft 6in
Total weight	117 tons
Maximum axle load	19½ tons
Normal maximum speed	75 m.p.h.
Starting tractive effort	30,000 lb
Maximum tractive effort in low-speed range	45,000 lb
Maximum speed in low-speed range ...	50 m.p.h.
Fuel capacity	6 tons (say, 500 miles)
Maximum turbine temperature	1,300 deg. Fah.
Maximum heater temperature	1,560 deg. Fah.
Maximum speed of power turbine... ...	8,000 r.p.m.

Exhaust air from the work turbine is partly used for combustion and partly to reduce the temperature of the burnt gases before they enter the air heater. These gases give heat through the walls of the tubular air heater to the compressed air, which is the working medium, on its way to the turbine.

The compressor is driven by the high-pressure turbine and the low-pressure turbine provides the power output. The torque characteristics of the power turbine resemble those of the conventional steam locomotive, permitting direct drive.

A two-stage gearbox gives a choice of gears for passenger and freight work. Top speed in normal running, when geared for a tractive effort at starting of 30,000 lb, is 75 m.p.h.

Train heating is provided by a steam boiler heated by the exhaust gases from the air heater on their way to atmosphere.

Closed-Cycle, Coal-Burning Gas Turbine.—In the closed-cycle gas turbine, as in the externally fired open-cycle engine just described, the products of combustion do not pass through the main turbines. In examples of the closed-cycle engine so far built this clear advantage is to some extent neutralised by the fact that the combustion products necessarily pass through the turbine used for supercharging the air heater. With air heaters running at atmospheric pressure, however, any ash in the products of combustion cannot attack the rotating machinery and its damaging effects are confined to the air heater tubing. It is with this version of the closed-cycle engine in mind that the Ministry of Fuel and Power has ordered from John Brown and Co., Ltd., an atmospheric coal-burning air heater to be run with either the 500 h.p. John Brown experimental closed-cycle gas turbine or with a 1000 h.p. engine which the firm has in hand. The cycle arrangement is shown in Fig. 12. The air heater (Fig. 13) has a straight-through type of combustion chamber on which a great

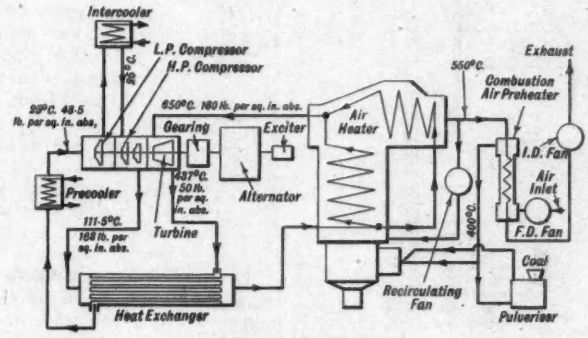


FIG. 12—*John Brown Coal-Fired Closed-Cycle Gas Turbine Plant with Atmospheric Air Heater*

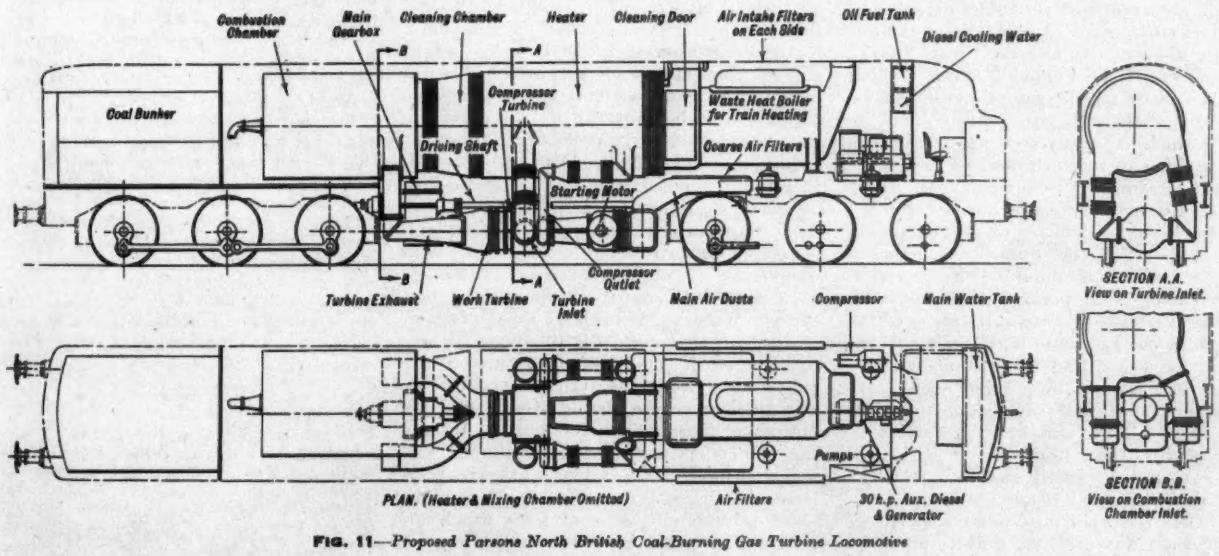


FIG. 11—*Proposed Parsons North British Coal-Burning Gas Turbine Locomotive*

* Institution of Mechanical Engineers. Thomas Hawksley Lecture, Abstract. November 16th.

† Chief Scientist, Ministry of Fuel and Power.

deal of rig testing has already been accomplished. This refractory-lined chamber has been run as both a dry-burning and a slagging chamber and has given very encouraging results.

The experience of slagging which has been obtained will be of value in the development of a cyclone slagging chamber which the Ministry has ordered as an alternative to the straight-through chamber.

Coal Pumps.—In all the gas turbine plants which I have briefly described, coal has to be injected into the combustion chamber

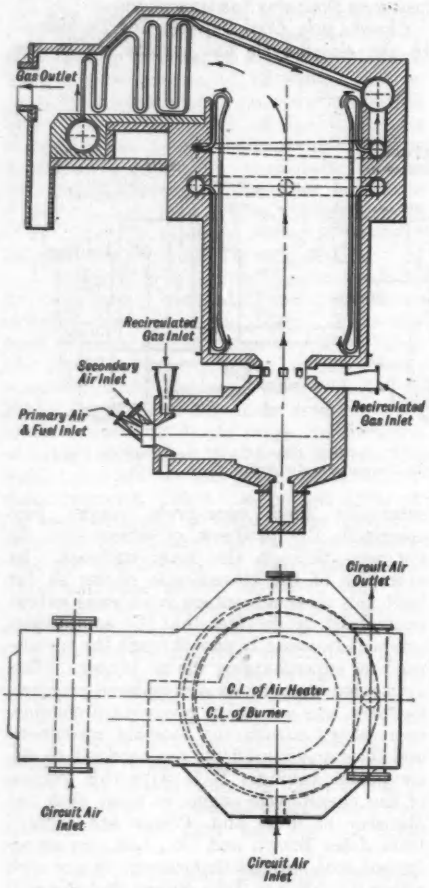


FIG. 13—*Arrangement of Coal-Fired Air Heater with Atmospheric Combustion*

and, except in the locomotive engine, against a pressure of several atmospheres. Though on test rigs lock hoppers can be used to do this, the only practically satisfactory solution is a good coal pump. Two coal pumps have been developed to an advanced stage by the Incandescent Heat Company. One, which has been made for the gas producer test rig (Fig. 9) is of the rotating disc type, and the other, which is a private venture of the company's, is of the reciprocating ram type.

In the rotating disc pump, coal is fed under gravity into small cylindrical pockets situated on a pitch circle diameter of approximately three-quarters of the overall diameter of the disc, which is mounted horizontally. The bottoms of the pockets are sealed with small spring-loaded valves. Rotation of the disc causes the pockets, filled with coal, to pass under a seal into the pressure air discharge line, the air flow being such as to unseal the pockets and scavenge them of their coal. Before the empty pockets arrive at the charging chute for refilling with coal they pass under a small suction port which discharges their pressure air content.

In the reciprocating pump, a charge of air-coal mixture is drawn under a small depression through a rubber ball valve into the cylinder on the outward stroke of the ram, and then this mixture is compressed and finally discharged through another ball valve into the high-pressure line during the inward stroke.

Successful preliminary running has been done on both types of pump against pressures of from 3 to 6 atmospheres with pulverised coal.

The Use of Available Gases from Coal

So far, I have been describing ways of using coal directly as a fuel. Two familiar derivatives from coal are also the subjects of interesting experiments. One of these derivatives is that unpleasant concomitant of coal mining—firedamp. The other is coal gas.

Open-Cycle, Firedamp-Burning Gas Turbine.—It was pointed out by C. H. Secord in 1948 that the methane or "firedamp" occurring in small percentages in the ventilating upcasts from mines was sufficient, if it could be converted into useful energy, to run all the colliery machinery in Britain. The methane usually occurs in amounts less than 1 per cent, though in a few pits figures above 1 per cent are recorded.

One way of using some of this available energy is to use the upcast gas, instead of normal air, under steam boilers. Whilst it would be better than discharging the upcast to waste, this method would only convert about 15 per cent of the methane in the upcast.

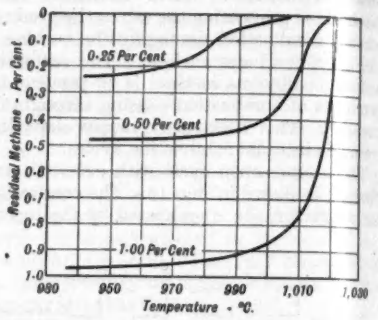
Secord proposed that the upcast methane-air mixture should be used directly in a gas turbine and so permit pithead generation of electrical power from a free fuel.

This proposal clearly depended upon finding a practical means of burning such an exceptionally weak mixture as 1 per cent or less of methane in air. R. G. Voysey proposed for this purpose a "temperature booster" which is, in effect, a regenerative heat exchanger combined with a combustion chamber. This device depended upon the assumption that if the weak mixture were sufficiently preheated it would oxidise at a reasonable temperature and the heat of combustion was proposed as the means of preheating.

It was clearly essential at the outset to determine the conditions for combustion of weak methane-air mixtures, and this work was undertaken by Sir Alfred Egerton and his staff at the Imperial College.

The experiments which they did are of absorbing interest and have a scientific importance beyond the immediate reasons for their being done. They will be dealt with fully by those responsible for their conduct. I will here, however, reproduce the set of curves (Fig. 14) which permitted practical design work on a firedamp-burning gas turbine to be begun. From these curves it can be seen that if preheating to about 1000 deg. Cent. (1832 deg. Fah.) is arranged, then combustion, or, more accurately, nearly complete oxidation, occurs. A simple firedamp-burning gas turbine with cycle temperatures corresponding to this figure was the original conception (Roxbee Cox, 1951).

It was soon apparent, however, that, except for the abnormal case of very gassy pits, this cycle led to a derated gas turbine which, on economic grounds, was undesirable, and the original conception was modified to the idea of a gas turbine of optimum thermodynamic design burning the upcast gas and an auxiliary fuel. This was a far more useful and interesting proposal than the original one, for at all collieries there is a supply of coal fines which are generally not worth while transporting, so that the target became a gas turbine plant based on the two free fuels which a pit can provide—upcast gas and low-grade coal. We visualise, therefore, an ultimate fusion of our work on weak methane-air mixtures and our work on the coal-burning gas turbine. In the meantime, the obvious practical course is to develop a gas turbine which burns the upcast gas together with an



Results of experimental work done at Imperial College

Methane from Point of Air colliery. Mean residence time, 4·75–5·0 milliseconds; separate preheating of air and methane. Reactor, ¼in inside diameter by 2½in long. For 10 milliseconds residence time, temperatures are lowered by approximately 30 deg. Cent. (by 54 deg. Fah.).

FIG. 14—*Oxidation of Weak Methane-Air Mixtures*

auxiliary fuel more tractable than coal fines. This is our immediate target. The most attractive auxiliary fuel, and, indeed, the most natural one until coal itself is used, is coke-oven gas, though for experimental purposes we shall, as convenient, use any other available auxiliary—oil, town's gas or producer gas—in connection with which the possibility of combining the producer gas gas turbine idea with the firedamp gas turbine idea is kept in mind.

(To be continued)

A Small Drilling Machine

A NEW ½in capacity drilling machine, known as the "Startrite Speedway," is now being made as a bench and a floor model by the Startrite Engineering Company, Ltd., Gads Hill, Gillingham, Kent.

The ground tubular column of this machine is mounted rigidly in a heavy machined baseplate and carries an adjustably mounted headstock, which incorporates all the spindle mechanism and controls. The spindle is supported in a ground quill carrying one ball thrust and two journal bearings and two heavy journal bearings, on which the pulley is mounted, take the horizontal thrust of the drive. A feed rack is cut in the quill and quill wear can be taken up through a phosphor bronze pad adjusted through a knurled disc. The spindle travel is 3½in and an adjustable balance spring is fitted for its quick return.

Standard machines are fitted with a ½ h.p. 1425 r.p.m. electric motor and the drive is taken from this vertically mounted motor at the rear of the head through four-step vee pulleys. Four spindle speeds from 480 to 4220 r.p.m. are available. A machined table with a working surface 11½in by 10in can be tilted through 90 deg. and is positively indexed in the true horizontal and vertical planes and at 45 deg. A 30in column is fitted to the bench machine and a 60in column to the floor model, the table being adjustable over the full column height.

BUSINESS EFFICIENCY EXHIBITION.—The thirty-eighth Business Efficiency Exhibition is to be held at Bingley Hall, Birmingham, from February 20th to March 1, 1952. As usual, it is being organised by the Office Appliance and Business Equipment Trades Association, 11–13, Dowgate Hill, London, E.C.4.

The Institution of Mechanical Engineers

AT a general meeting of the Institution of Mechanical Engineers, last Friday, November 23rd, the following Steam Group paper was presented and discussed :—

CONTROL OF BOILERS FIRED BY SOLID FUELS IN SUSPENSION

By LLEWELLYN YOUNG

In this paper are discussed those characteristics of boiler design and performance which have favoured the parallel development of automatic control of boiler auxiliaries.

Consideration is given to those temporary conditions which arise during periods of load change and which, if not accurately estimated and followed by the necessary corrective action, may lead to over-regulation of firing rate or feed water supply. Instruments are provided to determine and inform the operator of the necessary action to be taken, and manual distance control eliminates the laborious duties of routine readjustments necessary to maintain efficiency. In this field automatic control has many advantages and is quicker and more accurate in response than the human operator.

The theory of elementary forms of automatic control devices is dealt with simply, and the mechanical means by which these theoretical requirements are met are described, employing pneumatically operated devices. Examples are given of the use of standard apparatus in building up a composite control system, and the more complicated installations of boilers fired by spreader stokers, pulverised fuel and cyclone furnaces are dealt with.

DISCUSSION

Mr. W. B. Shannon said the paper was factual, it was restrained and it was modestly free from the provocative claims which were sometimes made in papers and might incite lively, but not necessarily, engineering criticism. The provision of automatic control arose, as the author had shown, from a desire to get more efficient operation, and the author had rightly stressed the fact that it facilitated the boiler operator's duties. The reactions of those closely concerned with the operation of boiler plant supported the conclusion that automatic control was complementary to the operator. He had recently met an experienced operator who had not previously been associated with such equipment, and after some months' contact with automatic equipment this operator had remarked that he had never before had unrestricted opportunity of studying combustion conditions and he was completely converted to the automatic control system. On the efficiency aspect, which the author had not stressed too much, they should remind themselves that on a stoker-fired boiler the auxiliary power might be of the order of 4½ to 5 per cent. On the p.f. plants it was much higher. On a good plant it might be 5½ per cent and on not so good plants it might be up to 7½ per cent. Therefore anything which could be done to reduce the auxiliary power and increase the efficiency of operation was most attractive to power station engineers.

One or two points, derived from some experience with most of the alternative systems, occurred to him as worthy of comment. He would like the author to explain in more detail how the automatic control dealt with fuel change, particularly when there were quite drastic changes in fuel characteristics. His own feeling was that the human operator was necessary even though the change might not occur without some warning.

He believed that automatic control was almost an essential feature of unit plants and would be a safeguard owing to its immediate response in the event of the failure of a mill group. If such a thing occurred, the pressure would fall, and the automatic control would then call upon the remaining group or groups to operate to capacity and adjust the fan plant to suit. That would tend to avoid a complete shut-down of plant, although in the case of a unit plant of only two mill groups the fall in pressure would be too severe even for the automatic equipment to deal with the situation. In those circumstances there was a case for a pressure regulator on the inlet to the turbine. A point on which they might be at variance with the author was that the air flow must include the tempering air to the mills. Some manufacturers and, he believed, some users still did not appreciate the result of that omission, particularly in suction plant. If tempering air to the mills was not taken into account erratic operation would result according to his experience. Another point on which the author might be able to help them was on the control of furnace draught. In some quarters there was a preference for the control through impulses being sent to the f.d. fans because most fluctuations were due to damper changes and through the secondary and tertiary air. It might be that the impulses could be given to both the f.d. and i.d. fans.

The author had not pressed the matter of the saving in manpower. It was clear from experience that the number of operators could be reduced by the use of automatic equipment. In fact, on very large boiler plants it was possible to operate with one stoker to two boilers. But might that not be offset by the additional maintenance which was necessary to keep the equipment up to standard ? The maintenance personnel might be graded higher than the stokers controlling the boiler plant.

Mr. I. F. G. McVicker said that the author had drawn an interesting parallel between aircraft controls and boiler controls. He would like the author to cast his mind back some seventeen or eighteen years to the time when the control systems were electrical. The author had stated in his paper, very categorically, that air was needed, and in presenting the paper he had said that he did not care for hydraulic means. He would be glad if the author would comment on that, because modern aircraft controls were now turning to electrical operation and it seemed to him that many of the characteristics, especially the non-linear ones, could be met electrically more simply than by air.

MILL CONTROL TO AIR CONTROL

Mr. H. H. Walton had noted with great interest the reference to first and second derivative relays. The former were occasionally employed in the control of continuous processes, such as were encountered in the chemical industry for example, but he wondered whether the advantages of those additional terms in the control equation were actually realised in their mathematical sense when the impulses derived from the relays were applied to large power cylinders using a compressible fluid such as air as the operating medium of which the "constants" must change with differing conditions of load. Their calibration, too, might be rather difficult if any subsequent readjustment were needed.

The mill controller, marked *MC* in some of the diagrams, was included for the purpose of adjusting the effect of a given signal according to the number of mills in use. He wished to know whether that device operated in definite steps or was variable in its settings. It might, for example, be necessary, due to change in fuel quality, to bring in an additional mill to sustain the same boiler load. Thus, the operation of three mills, each at two-thirds of the rating at which two mills were previously operating, would not, for that very reason, provide the same rate of fuel input, and some other value of the impulse signal would be required by the mill controller to maintain the load without change of steam pressure. Moreover, further readjustment might possibly be necessary due to differing excess air requirements for the altered quality of fuel. Other factors, too, such as mill wear, moisture content and grindability, might also call for similar readjustment of the primary impulse pressure relative to boiler load.

In connection with the control of steam temperature, the author had referred to an initiating signal taken from boiler load. What was the origin of that signal ? Measurement of the flow of the gases could, he believed, present difficulties, as fluctuations in differential could cause continuous changes in the control valve position at a rate which was far in excess of the rate of temperature change. If conditions required a "cascaded" form of control, initiation of the controller from temperature measurement after the primary superheater would probably be more effective. At that point the effect of other factors influenced by load change would be detected. On pulverised fuel fired boilers tertiary air was not controlled owing to the usually complicated arrangement of dampers, nor, in fact, were the dampers invariably readjusted manually after a load change, except perhaps as an afterthought. The change in tertiary air distribution could, nevertheless, have a considerable effect on the superheater temperature, either increasing it or decreasing it, according to the flame condition and the type of superheater.

He was also interested to see from the boiler diagrams presented by the author that measurement and control of the combustion air were made at the forced draught fans. Where measurement in that way was practicable, it had, in his opinion, much to recommend it. The air flow, measured by means of a venturi tube or orifice plate in the forced draught duct or by means of a nozzle constructed over the fan eye, could be determined fairly accurately and was uninfluenced by wide changes of temperature. The alternative method of inferring air flow by measuring the flow of the gases through the boiler passes, air heater or other position in the gas path, where a representative differential pressure could be secured, sometimes presented difficulty. The differential changes according to the cleanliness of the boiler could be influenced by buoyancy effect, while air heater leakage or recirculation added to the inconsistency of that reading. When there were, as was usual, two forced draught fans, two air flow measurements could be taken, a measuring regulator being used for the control of each fan. The method had the advantage of balancing the air flows, especially if the hot air ducts to the burners were segregated and, where there were separate air heaters, would compensate for changes in their respective resistances as they became fouled. That arrangement left the control of furnace pressure to the induced draught fans and raised again the issue as to whether that control should be on the basis of forced or induced draught. Complete reliability of the induced draught fan control equipment was, of course, essential, but experience gained over past years had, he thought, conclusively shown that

that had been well established. The method described by the author involved control of both the forced and induced draught fans in parallel with final correction of the induced draught by the furnace pressure regulator. Another method was to make the furnace pressure regulator a unit operating entirely independently of the other boiler control equipment and its associated air impulses, so that in all circumstances it would maintain a balanced condition of draught. That method had found a good deal of support. It undoubtedly meant that the forced draught and induced draught fan controls acted in sequence rather than in parallel, so that the regulator must first detect the change in combustion chamber pressure produced by the forced draught fans before it could operate. In practice, that system worked quite satisfactorily if the furnace pressure regulator was suitably sensitive and by proper selection of pressure tapping and correctly engineered control means. Independent adjustment of the stability of both regulators had, of course, to be possible so that the changes produced by the one were within the ability of the other to take effective action, and that was usually done by individual tuning. In a co-ordinated system of regulators, as in an automatic boiler control system, it had to be borne in mind that the rate of response of the system was determined by the rate of response of the slowest effective auxiliary to the boiler.

Another consideration that, in his opinion, supported control of furnace pressure by means of the induced draught fans and control of air flow by the forced draught fans was the increased burner stability to be expected. The flow of air to the burners should be steady in order to minimise flame fluctuation. Any tendency towards unstable operation due to changes in calorific value or volatile content of the coal would cause pulsations of pressure in the furnace. If the furnace pressure regulator acted on the forced draught fans it would attempt to counteract the pulsations by altering the air flow to the burners. That variation in air flow to the burners would usually aggravate flame instability, sometimes to the extent that loss of ignition occurred, especially at low loads or with relatively cool furnace walls.

The furnace pressure regulator ought, after all, to have one function only; that was, to withdraw the products of combustion while maintaining steady furnace conditions, and ought not to influence other factors such as secondary and tertiary air, which was the case if the forced draught fans were employed.

In connection with the control of boilers with spreader stokers, he wished to invite the author's opinion on the relative merits of correcting air flow or fuel feed from the steam-flow/air-flow controller. If the boiler was considered as being fired preponderantly by the fuel in suspension, correction of air flow, being the factor to which the boiler was less sensitive, would seem to be preferable. On the other hand, if the major heat release was from the fuel bed on the grate they approached the conditions of the ordinary stoker-fired boiler, which was primarily responsive to change in air flow through the fuel bed, and correction of the fuel feeder regulator rather than of the air flow regulator would appear to be better. There was probably little to choose between the two methods.

Finally, the author did not refer at all to the automatic control of the relatively high-pressure secondary or overfire air used with that type of stoker. That had been successfully carried out with chain-grate stoker-fired boilers, and it would seem to be even more important in the case of the spreader stoker where the secondary air might amount to quite a big proportion of the total air required for combustion. Its correct proportioning and distribution in relation to load must influence flame development and condition and, thus, the superheater temperature, and render close control of the final steam temperature even more difficult to attain.

CO_2 Analysis and Open and Closed Loops

Mr. G. H. Toop said that the author condemned CO_2 analysis as a means of control because of errors introduced by stratification and time delay. It was, however, a fact that large numbers of p.f. fired boilers were manually controlled by reference to a CO_2 instrument, and it appeared that the steam/air system was itself dependent upon gas analysis for its calibration. There was also the fact that the oxygen meter described would presumably be subject to the same errors. It would seem a reasonable proposition that, by due attention to the method of sampling and by reducing the lags due to sampling pipes, the difficulties could be overcome and the dead time reduced to the order of thirty seconds or less. The use of an oxygen meter as a direct controller of excess air then presented an extremely attractive proposition, since a true closed loop control was obtained and empirical relations such as steam/air corrections were unnecessary. It would be of interest to have the reasons for utilising both steam/air and oxygen analysis control, in addition to the open loop relationship, in the author's scheme 6, since it would appear that both those systems were attempting to control the same function, and presumably, therefore, only one could employ integral action and give the overriding control.

The second point he wished to raise was in connection with the wide use of "disturbance feed-back loops" or "open loops" in conjunction with true error-actuated closed loop controls. In many cases that practice was completely justified, but he felt that the very widespread use of open loops might give the impression that they were a good thing in themselves. His contention was that open loops were only justified when all the possibilities of closed loop control had been fully exploited, and every effort made by the plant designer to remove or at least to reduce the inherently bad control characteristics which rendered them necessary. When an open loop could not be avoided it was necessary to ensure that all regulators which were in parallel to the same control signal should be approximately matched in range and characteristic, since there were no corrective feed backs in the open loop and it was necessary to rely on the closed loop control to take out any errors which were applied in that way. A unit change of control pressure should always represent approximately the same change in controlled variable, and that was often difficult, if not impossible, to attain unless the additional complication of a local closed loop flow or speed control was incorporated. In fact, while in diagrams the use of those disturbance feed back loops looked simple, in practice they were full of difficulties and complications in the actual engineering of the job. In presenting his paper the author had rather stressed the need for the points which he had mentioned, although he had not stressed them in the paper itself.

The author advocated an open loop correction from boiler load to overcome the time lags caused by the thermal capacity of superheaters. In practice it might be found that the degree of improvement to be obtained in superheat temperature control by that means was relatively small. As a concrete example, the speaker quoted the case of a superheater which had a multi-capacity dead time of four to eight minutes (depending on the load) between moving the temperature control valves and detecting the resultant temperature change. The dead time between an alteration of gas flow past the tubes and detecting the resultant temperature change was of the order of half a minute. The maximum improvement obtained, therefore, if an open loop correction was applied from gas flow as an indication of boiler load, was the difference between the inevitable divergence occurring during a four-minute dead time and that occurring in four and a half minutes. That was at top load and under ideal conditions. Obviously, at lower loads with an eight-minute lag the difference would be between eight minutes and eight and a half minutes, which was also negligible. At present, by improved design of superheaters, plants operating at similar temperatures were being built and operated with the major dead time reduced to one minute or less, so that the inevitable divergence was drastically reduced without any additional control gear to the normal three-term temperature controller.

Generally it could be said that if the disturbing potential entered the control loop relatively close to the measuring and controlling instrument and remote from the means of regulation an open loop correction from the disturbance was of correspondingly small assistance in preventing a divergence of the controlled variable from the desired value. In that connection it could be mentioned that a system of true closed loop cascade control had been developed for inter-stage desuperheater systems which not only prevented any steam temperature disturbance entering the secondary superheater from the primary, but also introduced such phase advance into the secondary control loop as to give considerable increase of cycling speed with consequent more rapid recovery after disturbance. In the case of tilting burner and gas diversion superheat control the regulating potential was applied at the same point as the major disturbing potential—that was, to the full length of the superheater tubes—with resultant good closed loop control, since the time lag in that case was usually less than a minute.

Finally, it appeared to him that the whole emphasis of the paper was upon methods of applying control by a particular type of control apparatus rather than upon the underlying scientific reasons for adopting various practices. Now that the theoretical considerations of plant control were becoming more clearly defined as a result of work by Rutherford and others, it seemed that the author, with his long and varied experience of boiler control, might have given them some indication of his ideas as to ways by which design could be altered to improve the inherent controllability of boilers. In the past it had been inevitable that the plant was designed first and any bad control characteristics had had to be overcome later by complicating the control apparatus. There seemed to be no justification for that practice to continue in the future.

The author made a short reply and the meeting then ended.

Vehicle Suspension.—"Problems of Motor Vehicle Suspension" is the title of a booklet by Alan Hodgson, of Richard Berry and Son, Smethwick, Staffs. These notes contain a general description of suspension problems and requirements, followed by a description of the design and manufacture of laminated leaf springs.

After the Election

(Contributed)

SPEAKING at a Labour Party meeting in December, 1949, Mr. Herbert Morrison—then Lord President of the Council—uttered some words which may well be repeated to-day: "The best incentive of all," he said, "is service. All great patriots, all great scientists and artists, all craftsmen and, in fact, men and women of all kinds, from housewives and nurses to engine-drivers, have always known that and have long been guided by it. . . . If we cannot ensure that our society rewards the useful a lot better than it rewards the socially unjustifiable and useless, useful citizens, managers and professional men, as well as rank and file workers, will be discouraged and will actually lose efficiency." Now that the cut-and-thrust of a general election has come to an end, the nation will hope that reality may take the place of illusion, particularly the slow-dying illusion that a nation or an individual can reap where it or he has not sown. The horizon which we all face is studded with storm signals. To waste time on recrimination is to flog a dead horse and does nothing to assist in meeting, and if possible surmounting, our manifold difficulties. We have indeed enough on our hands if we set out to strive for survival and to achieve it calls for united efforts of an intensity not hitherto known in time of peace. To the engineer who has any knowledge of world conditions, the plain need of the times is that all citizens shall so act as to bring into service the full resources of the nation in imagination, skill and industry. Without harmony, this marshalling of strength is impossible and harmony cannot be reached without a knowledge of the facts. Too many among us fail to realise the potency of good will. Too many among us criticise and contradict when we should be earnestly looking for points on which we can agree and co-operate. The responsibility here rests mainly on those who are best equipped mentally and who should realise that such equipment is something which places on them a higher responsibility. It is a deplorable thing that so large a fraction of our population should have been allowed to believe that the effusion of public money can proceed without ultimate public impoverishment. Another and shameful thing is that so little effectual attention is given to the vital need for avoiding what General Eisenhower has described as "the economic and human deterioration incident to industrial strife."

No one will doubt the clamant need for the maintenance of that high quality which, in the past, has been regarded as a characteristic of British engineering products. One of our basic problems is to maintain this quality in the changed circumstances which are associated with and relate to mass production. It can only be maintained where there is pride in craft and that is, to a preponderating extent, a human question. Napoleon's proposition as to war holds good in engineering production: "Les trois quarts sont des affaires morales, la balance des forces réelles n'est que pour un autre quart." It is here that the effect of engineering leadership and the establishment of cordial relations between managements and men can play so influential a part. The responsibility of management is great indeed and to whom much is given from him shall much be expected. A working atmosphere at the top permeates all the way along and a working atmosphere seasoned with a knowledge of human nature is almost certain to produce great results. We want more of the spirit of the engineer and less of the spirit of the accountant. "Only he who knows is able to lead" and where engineering industry is led by engineers it is always more likely to function with that efficiency which results from harmony. In his recent Presidential Address to the Institution of Civil Engineers, Mr. A. S. Quartermain, remarking that mediocrity and accountancy are not able to solve our problems, went on to remind us that "no amount of skill and training will be sufficient unless we add also something of the spirit of Brunel. He lived at a time when this nation was creating its greatness and recognised that only by unflinching determination and incessant effort could obstacles be overcome."

There is another aspect which we do well to bear in mind: encouragement is communicated more freely by example than by precept and it operates best where there is a knowledge of human nature and of the differing endowments of individual men. Nature has to be considered as well as technology and economics. "If you drive nature out with a pitch-fork," says a wise ancient, "she will soon find a way back." Some of us need to be reminded of that wise admonition, uttered so long ago by Horace, to the effect that even if we do not ourselves possess a cutting edge, we may, as whetstones, be able to sharpen the edges of others. It is no easy matter to bring home the need for every man to do his utmost, whether he have a cutting edge or whether he must act as a whetstone. Nevertheless, we are all in this together and it is only by each man rendering the best account of himself that we shall be able to accumulate that national force without which nothing can avail to save us from decline.

Atomic Central Heating System at Harwell

As announced by the Ministry of Supply, the first atomic central heating plant in the world was inaugurated last week at the Atomic Energy Research Establishment, Harwell, where a building containing eighty offices draws heat directly from BEPO, the large experimental atomic pile. Tests carried out on the new installation earlier this month are stated to have been completely successful. Ultimately two, or perhaps three more buildings will have similar heating systems and, by using heat that would otherwise be dissipated from the pile, coal consumption within the establishment will be cut by 250 tons this winter and by at least 1000 tons a year thereafter. The estimated capital cost of the installation is £15,000 (1950 prices) and, after allowing for all incidental expenses the cash saving is estimated to be £2650 a year.

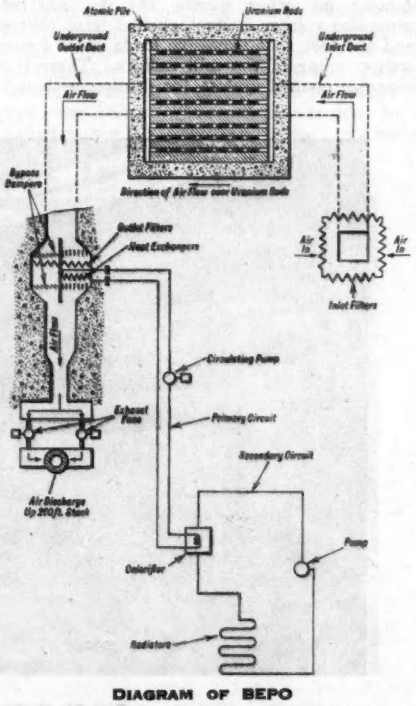


DIAGRAM OF BEPO CENTRAL HEATING SYSTEM

The total floor area now being heated by the new system is 32,000 square feet and the volume is 330,000 cubic feet. For the requirements of this building the installation has a design heat output of 1,000,000 B.Th.U. per hour. For the complete installation the heat exchanger will have a maximum output of 7,000,000 B.Th.U. per hour.

Very little technical information is available about the new plant but the accompanying diagram gives an outline of the system. The hot water circuit itself is conventional except that it derives its heat indirectly from a heat exchanger installed in the outlet air duct of the pile's air cooling system. At that point there is a by-pass fitted with a damper, which can be adjusted to vary the proportion of the air flow passing through the heat exchanger. Hot water from the primary heat exchanger is circulated (by a small pump) in a closed circuit to a secondary water-to-water heat exchanger, which provides non-radioactive hot water for space heating and domestic supplies. At present the air temperature at the primary heat exchanger is 135 deg. Fah. and the water itself is heated to 130 deg. Fah.; but, in 1952, when modifications to the pile have been completed, these temperatures will be substantially increased.

The installation was carried out by the Ministry of Works in collaboration with the engineering division of the Atomic Energy Research Establishment. The primary heat exchanger is a Serck equipment, which measures 10ft by 10ft by 2ft 6in overall.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

SINGLE-BUCKET EXCAVATORS OF THE CRAWLER-MOUNTED, FRICTION-DRIVEN TYPE

No. 1761 : 1951. This new standard deals with crawler-mounted, friction-driven single-bucket excavators covering face shovels, draglines, drag shovels, skimmers, grabbing cranes, cranes and pile drivers, the shovel or bucket capacity ratings being from ¼ to 2½ cubic yards. The seven types of excavators covered are illustrated and defined, and definitions of a number of the terms used in connection with these machines are also included.

The object of the specification is to secure the general observance of such fundamental principles as appear desirable to ensure reliability and safety without impeding the excavator manufacturer in his selection of the most appropriate design for the purpose. It should be noted that the factor of safety is arrived at on a different basis from that used in the crane standards. For excavators this factor is related to the maximum engine output and not to the maximum working load; this results in the use of the machine as a crane being limited by stability conditions.

In general lay-out and contents the standard follows substantially similar lines to the standards dealing with cranes. Stability is dealt with in some detail, and careful consideration has been given to the lay-out of the controlling hand levers and pedals. An appendix dealing with the design of struts has been drawn up on the same basis as that for the new standard for mobile cranes and follows the general method of application of the Perry-Robertson formula as adopted in other British Standards. It is probable that before long it may be possible to issue a supplement to amend the standard to deal with stresses in the excavator structure on similar lines to other British Standards, whereby the principle of using a factor of safety will be replaced by a specification of maximum permissible stresses and suitable factors for their modification to suit operating conditions. Price 6s., post free.

The Works of the Steel Company of Wales

No. V—(*Continued from page 652, November 23rd*)

Slabbing Mill and Hot Strip Mill

As each ingot is removed from the soaking pits by the charging crane, it is placed on a travelling tilting carriage and delivered to a receiving table of the slabbing mill. All of the equipment for this mill, some views of which are reproduced on this page and page 691, was supplied by the United Engineering and Foundry Company of the United States.

The ingot is carried along the 12ft long receiving table to a turning and weighing unit, the scale of which is equipped with indicating and recording instruments. An approach table 26ft 7in long then carries the ingot to the slabbing mill illustrated in Fig. 23. This mill has a roller table 31ft 5in long front and back, with a manipulator on the incoming and outgoing sides. The two-high 45in. by 115in reversing slabbing mill has a maximum lift of 68in; the largest slabs produced for sheets are 5ft by 8in thick, and for tinplate 18ft by 2ft 6in by 8¼in thick.

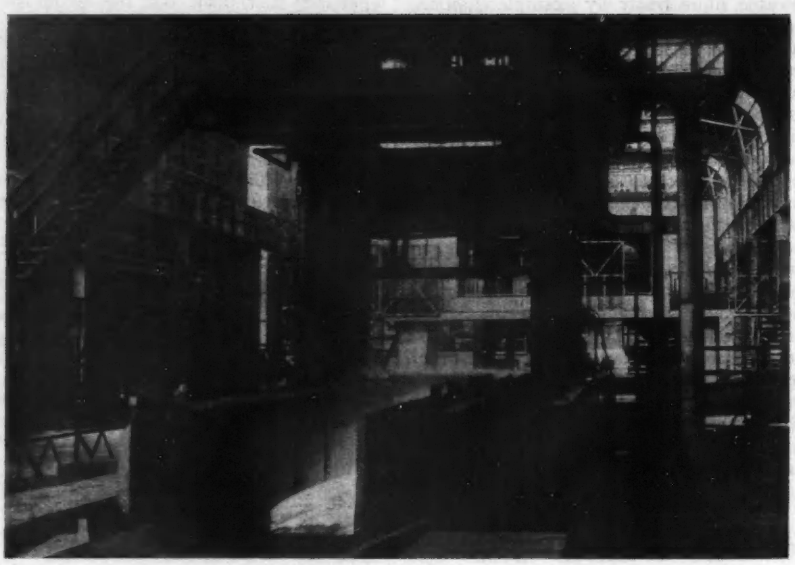


Fig. 23—Slabbing Mill with Slab being Rolled

Two English Electric reversing motors (Fig. 24), each having a peak rating of 27,600 h.p., 0/40/80 p.m., provide the drive to the mill. Each of the two 45in diameter rolls of the mill is connected directly, through universal spindles to one of the motors. In this "twin" drive there is no mill pinion housing and, therefore, no mechanical connection between the two motors except through the slab that is being rolled. Together the two motors are capable of exerting a peak torque of 3,600,000 lb-ft, which is available at speeds up to 40 r.p.m. At higher speeds, up to the limit of 80 r.p.m., the torque diminishes to the peak rating of 27,600 h.p. Each motor has two armatures, a construction which reduces the diameter and inertia of the motor and thereby reduces the reversal time. Further, the two-armature design allows the distance between the top and bottom shaft centres to be kept within reasonable bounds. The twin motor installation is supplied from an Ilgner set comprising four generators driven by an induction motor, with a flywheel for load equalising. Each generator is rated at 1850kW at 550V and the connections are such that the voltage to earth cannot exceed 1100V. The induction motor drives the set at a synchronous speed of 500 r.p.m. and is rated at 6500 h.p. to meet all calculated mill demands with a drop in speed limited to 20 per cent, the flywheel has a stored energy of 200,000 horsepower seconds.

In the operating pulpit there is a foot-operated master controller for both mill motors and their generators, whereby seven speeds are obtainable between standstill and 40 r.p.m., and six speeds between 40 and 80 r.p.m. The controller is in the field circuits of two special rapid-response exciters, which, in turn, control two main exciters connected in the motor and generator field circuits respectively.

This twin motor control scheme, which is comparatively new, is designed to achieve rapid reversal and change of motor speed. Among its other merits are its inherent generator voltage control, current limit control and the fact that excessive loads cause forced compounding of the mill motors. There is a separate control system for dealing with out-of-balance load currents, as between the upper and lower motors, the circuits being designed to hold the differential torque between the two motors at preset values to within +25 per cent. An important advantage of the exciter control system is that very few relays or contactors are required in the equipment; indeed, there are only two relays which have to operate frequently and the complete contactor board is only 7ft long. In all, the control the equipment consists of the contactor board, master controller torque and speed differential rheostat cubicle, and the series transformer for the Ilgner set.

Pressure lubrication is applied to the mill motor bearings, to the extra bearing carrying the outer end of the shaft extension over the lower motor, and on the flywheel bearings which, for safety reasons, also have mechanically driven lubricating pumps. Gravity lubrication is used for the other bearings on the Ilgner set. Flow relays and pressure relays give protection against failure.

All the main machines are forced ventilated by two recirculating systems—one for the motors and the other for the Ilgner set—including air/water coolers. An interesting refinement is that a small portion of the air passing through each machine, and carrying with it the brush dust from the commutator, is removed from the system by axial flow extraction fans and is replaced by an equal quantity of air drawn through an electrostatic precipitation filter which is included in each air circuit.

Power for the Ilgner set is drawn from the works 11kV system and excitation for dynamic braking of the set is provided by the mill 110V general purposes exciter. The main exciter set is fed from the 3·3kV system and the auxiliary exciter set from the 415V system.

Associated with the main mill drive are the drives of two feed rollers which are on each side of, and next to, the main rolls. Each pair of these four-feed rollers is driven through a gearbox by a heavy-duty English Electric "C.M.R." steelworks motor. These motors are fed from two variable-voltage generators having rapid-response voltage control and a current limit control system with exciters, as for the main drive. The feed roll systems are operated from the main contacts and from additional contacts in the master controller referred to above; approximate speed synchronisation with the mill is, therefore, automatically achieved.

From the slab mill the slab passes along roller tables first to a 40in non-reversing vertical edger unit before reaching the up and down cut shear shown in Fig. 25. Provision has been made for the installation of an automatic scarfer. The upper knife block of the shears descends on the rolled slab to prevent its movement, and the bottom block moves up to effect the shearing operation to length.

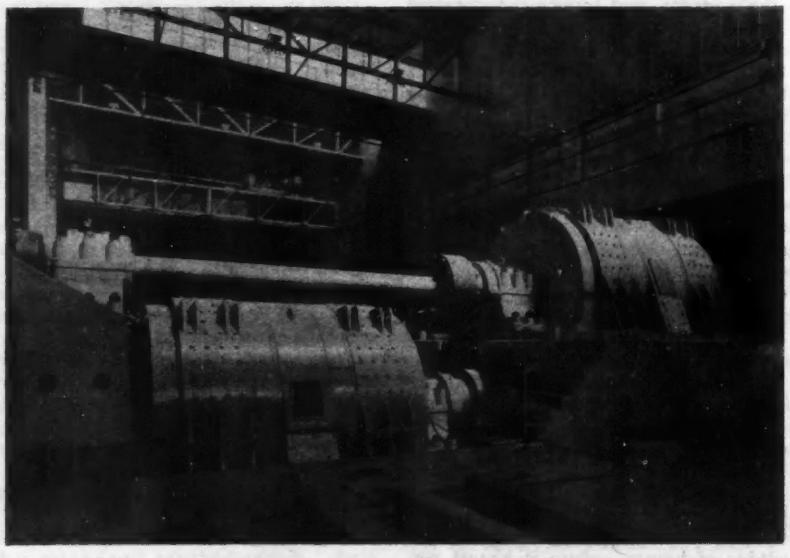


Fig. 24—Slabbing Mill Motors

This machine has a 19in working stroke with a knife pressure of 3,000,000 lb. It is geared to operate at a speed of 9 r.p.m. and takes slabs up to 10in thick by 60in wide. Cropped ends from the slab drop beneath the table into a skip resting under water and on an inclined conveyor arranged at right angles to the mill line which discharg s into trucks outside the building. Slabs pass from the plate shears via an enclosed conveyor to the slab yards.

Scale Breaker

Slabs are fed back to the rolling mill line from reheating furnaces, and drop on to a 182ft long roller delivery table, whence they pass to the 24ft long approach table of the primary scale breaker shown in Fig. 26. In this two-high mill, with 36in by 72in rolls, the slabs are rolled to detach the oxide scale accumulated in cooling from rolling temperature in the slabbing mill or from the reheating of the conditioned slab.

The scale breaker is driven by a Metropolitan Vickers 1250 h.p., 50/0/3300V slip-ring motor; its synchronous speed is 375 r.p.m., but it operates with an automatic slip regulator (described more fully below) in the rotor circuit, which produces a speed drop up to 20 per cent at twice full load, to utilise the energy of 20,000 h.p. seconds stored in the flywheel and thus relieve the motor and line of the peak demands of the mill. The motor has a maximum pull-out torque of two and a half times full load torque. It is mounted on a bed-plate having provision for sliding the stator along a pad in order to allow examination of the windings without excess.ve dismantling. The shaft is carried in two ring oil-lubricated sleeve bearings, each fitted with a dial thermometer provided with contacts to actuate an alarm device should the bearing temperature exceed a predetermined figure. In the event of the temperature rising still further, a bearing thermostat on each bearing operates another alarm and also shuts down the motor.

Closed air circuit ventilation is provided for the motor, the hot air from the machine leaving the stator by a central duct at the bottom and then flowing along a duct to an air cooler situated in a pit underneath. It next passes between water-cooled tubes in this cooler and out into the pit under the motor, whence it returns cooled to the motor via endbells, one at each end of the motor. Because of the comparatively low speed of the motor its own fans, fitted on the rotor, are insufficient to deal with the air quantity required, and a separate motor-driven centrifugal fan is fitted at the outlet of the air cooler. Dial thermometers, fitted with alarm contacts and mounted on the side of the stator, indicate the temperature of the air entering and leaving the machine, and actuate an alarm if the temperature of the inlet air becomes excessive. Tubular thermometers in the water piping indicate the inlet and outlet water temperatures at the cooler. Failure of the motor-operated fan causes the air temperature inside the motor to rise, operating a thermostat in the vent ducts in the stator core, which actuates an alarm and shuts down the motor.

For stopping the motor in any emergency, there is a conveniently situated push button which trips the forward circuit breaker and closes the reverse breaker. To prevent the motor reversing under this condition, a device on the end of the rotor shaft operates immediately the motor attempts to move in the reverse direction, and trips out the reverse breaker. Should emergency reversal be required, the operation of a push button cuts out the non-reversing device. A tachometer generator driven from the main shaft gives speed indication.

The rotor control gear consists of a liquid starter and automatic slip regulator which jointly start the motor and keep the electrical demand from the line reasonably constant under fluctuating mechanical load. Briefly, the slip regulator consists of a welded steel boiler plate tank containing three fixed electrodes connected to the motor slip rings, and three moving electrodes connected together electrically to form a neutral point. The tank is filled with a weak solution of washing soda in water, which is kept cool by cooling tubes carrying circulating water. Speed control is effected by varying the distance between the fixed and moving electrodes, and consequently the resistance in the rotor circuit. This variation is done by a torque motor fed from the secondary of a series transformer in the stator circuit. A variation of torque on the torque motor, which results in the dippers being lifted with an increase of load, or lowered with a decrease, causes a corresponding decrease or increase in the mill motor speed. This energy is taken from the flywheel under peak load conditions and restored to it during periods of light load, which tends to equalise the power demand from the line.

To ensure that, in starting, the dippers will be in the top position before the motor main switch can be closed, there is a limit switch on the controller operating in the closing circuit of the switch. The dippers are returned to this top position automatically on shutting down, by means of a pilot motor actuated by an auxiliary switch on the main oil switch which lowers a counterweight and raises the dippers when the main oil switch is opened. Another auxiliary switch operates on closing the main switch, reverses the pilot motor, which raises the counterweight and allows the dippers to fall until they reach a position where the torque motor takes charge. The mill motor then runs up to speed with its peak controlled by the torque motor. It will be seen that the starting is automatically initiated by the closing of the main oil switch.

For reverse current braking the connections to the torque motor must be reversed to prevent the current pushing the dippers down. This reversal is carried out automatically by reversing contactors in the torque motor stator circuit which change over with the main motor stator switches. The point at which the torque motor comes into operation can be varied to suit requirements either by variation in the position of the weights at the end of the lever at the bottom of the controller, or by variation of tappings on the series transformer, or by alteration of an external resistance in the rotor circuit of the torque motor.

(To be continued)

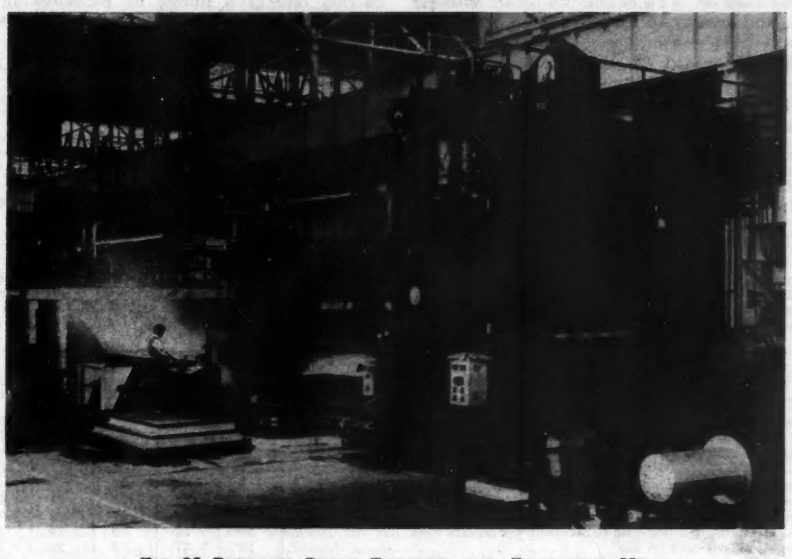


Fig. 26—Primary Scale Breaker and Broadside Mill

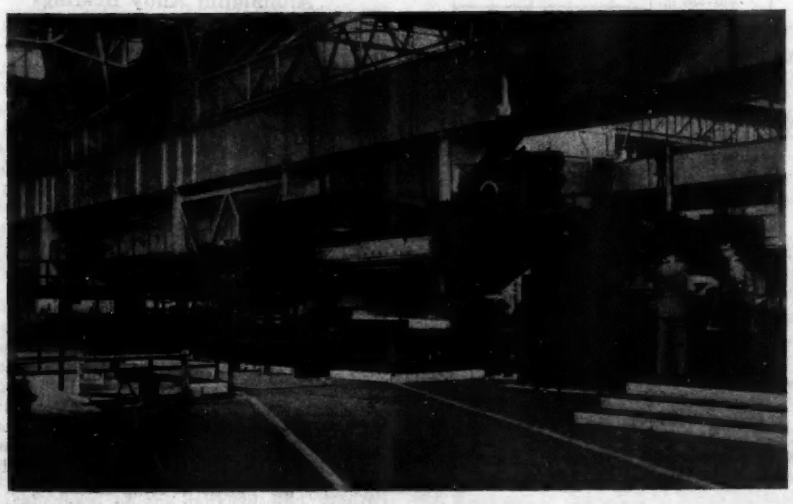


Fig. 25—Slab Shears

V.I.P. Aircraft.—Four special Handley Page "Hastings" aircraft now being supplied to Transport Command for "V.I.P." passengers are equipped with a hot-cupboard, griller, urn and refrigerator. A half-gallon water heater is fitted in the toilet. Four passenger seats have telephones connected to an exchange manned by a member of the crew, whilst a luminous call system, with push buttons at every seat, enables any passenger to summon the steward. Localised seat lighting is provided by an adjustable spotlight fitting, incorporating a 6W lamp, lens and simple focusing system in a housing with universal movement. All this equipment, which has been designed by The General Electric Company, Ltd., for aircraft installations, aims to combine electrical efficiency with minimum weight.

Metallurgical Topics

Beryllium Bronze Castings

THE beryllium-copper alloys are outstanding for high strength and corrosion resistance, making the wrought material specially suitable for springs and for parts of electrical machinery requiring high mechanical properties, including resistance to wear and fatigue. It may be recalled that the endurance limit in salt spray of beryllium bronze was found slightly to exceed that of 18 : 8 chromium-nickel stainless steel, and greatly to surpass that of any other steel.[1] In the form of castings the beryllium bronzes may, by temper-hardening, be made to develop the same useful properties. The original 2 per cent beryllium alloy has been modified and improved to give special advantages in different fields. These alloys can be produced as sand castings, or in permanent moulds, or by pressure, plaster mould or investment casting technique.

The production, properties and applications of the sand-cast alloys have recently been dealt with by J. T. Richards.[2] The paper contains a full account of four typical alloys whose composition is given in Table I, and the sand-casting technique and heat-treatment of the alloys are described in detail. The temper-hardening heat-treatment consists of water quenching from a temperature at which the alloy is wholly α-solid solution and reheating to a lower temperature at which precipitation of the γ constituent occurs. Heating must be carried out in a muffle or recirculating air furnace, not in a salt bath, as the surface of the alloy, although fairly resistant to oxidation at high temperatures, is damaged by salt. Figs. 1 to 4 show the change of hardness that the alloy undergoes. The accompanying properties are set out in great detail in the original paper, both upper and lower limits being given in each case, but in compiling Table II only approximate mean values of some of the properties are recorded as an indication of their trend. The fatigue limit is only one-sixth to one-fifth of the tensile strength of the fully aged alloy. The treatment for fully ageing is given in Table I as also are some physical properties of the sand-cast alloys in the fully aged condition. Over-ageing gives higher conductivity with increased ductility and loss of tensile strength. With some sacrifice in the final properties, the solution annealing may be omitted and the alloy, in the cast condition, subjected to the reheating or ageing treatment. The full range of properties attainable is thus greater than is shown in Table II, e.g., Brinell hardness may be up to 450, limit of proportionality up to 53 tons per square inch, and tensile strength up to 76 tons per square inch in the low-conductivity alloys, or 240, 29 and 49 respectively with a conductivity of 50 per cent of that of copper.

The alloy 20 C is the casting version of the standard 2 per cent beryllium alloy; 275 C was specially designed for plastic moulds and other applications requiring maximum hardness and resistance to wear; a recent application is for wire-straightening rolls; 10 C is suitable for parts requiring good electrical and thermal conductivity. It gives good service with little loss of strength up to 420 deg. Cent. and has been used for current-carrying components of heavy electrical equipment. In addition to its strength and conductivity, it has good elastic and impact qualities, which make it possible to combine current-carrying and spring members into a single 10 C part. The silver-bearing alloy 50 C with good conductivity, hardness and resistance to heat was specially designed for resistance welding dies and for electrode holders. Fortunately, these alloys, especially 10 C and 50 C, contain only a small amount of beryllium, so that the relative scarcity and prohibitive cost of that metal have comparatively little restrictive effect on their production and use.

TABLE I—*Composition, Treatment and Some Physical Properties of Sand-Cast Beryllium-Copper Alloys in the Fully Aged Condition (Richards)*

Alloy	20 C	275 C	10 C	50 C
Beryllium, per cent	1·90–2·15	2·50–2·75	0·45–0·75	0·30–0·55
Cobalt, per cent	0·35–0·65	0·35–0·65	2·35–2·70	1·40–1·70
Silver, per cent	—	—	—	1·00–1·15
Copper, per cent	Balance	Balance	Balance	Balance
Quenched in water from, deg. Cent.	800	800	925	925
Reheated for three hours at, deg. Cent.	340	340	480	480
Young's Modulus, pounds per square inch	$18{\cdot}5\times10^6$	$19{\cdot}0\times10^6$	17×10^6	16×10^6
Coefficient of linear expansion, 20–200 deg. Cent.	17×10^{-6}	17×10^{-6}	18×10^{-6}	18×10^{-6}
Electrical conductivity, per cent I.A.C.S.	20/25	18/23	45/50	48/53
Thermal conductivity, c.g.s. units	0·22/0·28	0·21/0·26	0·48/0·55	0·48/0·55

TABLE II—*Mechanical Properties of Sand-Cast Beryllium-Copper Alloys in the As-Cast (C.), Water-Quenched (W.Q.) and Fully Aged (A.) Condition*

Alloy	20 C			275 C			10 C			50 C		
Condition	C.	W.Q.	A.	C.	W.Q.	A.	C.	W.Q.	A.	C.	W.Q.	A.
Brinell hardness number	150	125	400	180	170	395	93	71	230	90	74	220
Tensile strength, tons per square inch	34	29	73	41	38	70	23	20	49	23	21	46
Limit of proportionality, 0·002 per cent offset, tons per square inch	11	5	51	20	9	42	7	4	26	7	5	26
Yield strength, 0·2 per cent offset, tons per square inch	20	14	60	24	13	54	9	5	28	9	6	33
Elongation, per cent on 2in	22	37	2	20	17	1	21	27	9	30	32	7
Reduction of area, per cent	23	25	1	23	10	1	21	22	7	30	37	7
Izod impact value, foot-pounds	73	95	8	62	27	6	82	105	40	77	102	50
Electrical conductivity, per cent I.A.C.S.:												
Minimum	17	14	20	17	10	18	32	20	45	32	20	48
Maximum	22	18	25	22	16	23	38	24	50	38	24	53

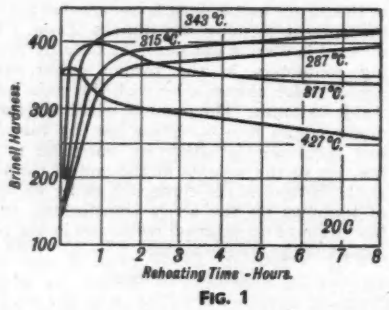


FIG. 1

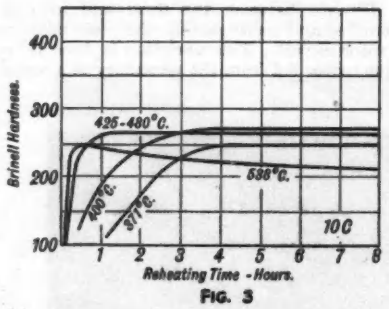


FIG. 3

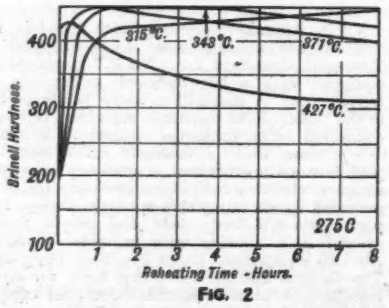


FIG. 2

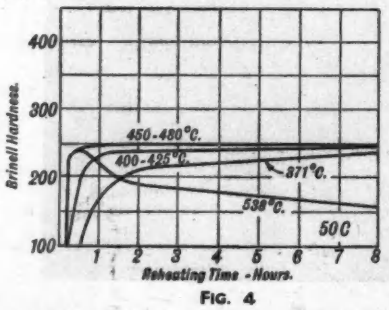


FIG. 4

FIGS. 1 TO 4—*Effect of Temper-Hardening Treatment on Beryllium-Copper Alloy Sand Castings (Richards)*

[1] D. G. Sopwith, Aeronautical Research Council, R. and M. Series, No. 2486 (1940).

[2] J. T. Richards, *Foundry*, August, 1951, Vol. 79, page 90.

Aluminium Alloy Bearings

DURING the inter-war years several patents were taken out covering the use of aluminium alloy bearing metals of somewhat complex composition, but nothing approaching development on a commercial scale was foreshadowed until the results of investigations by H. Y. Hunsicker and L. W. Kempf[1] became available and led to the standardisation of the 6·5 per cent tin alloy with small additions of copper, nickel and sometimes silicon. These aluminium-tin bearing alloys are used chiefly as single metal parts, preferably of substantial section, and are usually produced as permanent mould castings. They have a low coefficient of friction at high bearing loads, and a good resistance to seizing and to corrosion of the type encountered in bearings. The properties at room temperature and at temperatures reached by the bearings during operation were found to be markedly affected by the microstructure. Fatigue limit, for example, was greatly reduced as soon as the tin was present in sufficient quantity to form a continuous network in the matrix. Reduced ductility at elevated temperature was also associated with continuous interdentritic and intergranular films of tin. This necessitated

the use of chill castings and also limited the amount of tin which it was desirable to introduce, though by accelerated rates of solidification and by the addition of certain elements it was possible to obtain alloys of higher tin content and improved properties.

This work has been followed up by a research carried out jointly by the Tin Research Institute and the Fulmer Research Institute.[2] It was confirmed that tin distribution dominated the properties of the alloys. Discrete tin particles were associated with good values of ductility, but tin in the form of continuous films was detrimental. Modification of casting conditions alone was ineffective in completely preventing the formation of grain boundary films in high-tin alloys. The required structure could more readily be obtained by cold working followed by recrystallisation. Heat-treatment at 350 deg. to 500 deg. Cent. of the cold-worked alloy causes the tin to ball up in accordance with the requirement of minimum interfacial energy assisted by the recrystallisation of the aluminium matrix; and in this way alloys with 30 per cent of tin can be obtained with the desired microstructure. The tin particles are finer the greater the degree of cold work and the lower the recrystallisation temperature. Aluminium-tin alloys containing copper are age-hardenable and, if cold worked, quenched from 500 deg. Cent., aged for sixteen hours at 165 deg. Cent., show improved fatigue resistance with good ductility. They might be used for massive bearings, although the optimum composition still has to be worked out. Binary aluminium-tin alloys of high tin content are probably more suitable for backed bearings. Alloys containing 30 per cent of tin with or without 1 per cent of copper, offer a combination of fatigue strength and softness not hitherto attainable. They show greater resistance to fatigue and a much smaller fall in fatigue strength at raised temperatures than a typical tin-base Babbitt metal of approximately the same hardness.

There are, no doubt, other problems to be faced, connected with the thermal expansibility of these alloys and their bonding characteristics, but they show promise as new bearing metals with improved properties and tests on actual bearings in service will be awaited with interest.

[1] H. Y. Hunsicker and L. W. Kempf: *Trans. S.A.E.*, January, 1947, page 6.
[2] H. K. Hardy, E. A. G. Liddiard, J. Y. Higgs and J. W. Cuthbertson: *Metal Progress*, October, 1951, Vol. 60, page 97.

Strength of Cracked Mild Steel Bars

THE initiation of a crack in a stressed member during service endangers the stability of a structure, but does not mean that ultimate breakdown necessarily follows. As long as a crack moves slowly it can be stopped by reducing the load. This may occur automatically if the crack opens up. Stress concentration may then be cancelled by yielding, after which the crack will not deepen unless the load increases. Professor T. Isibasi[1] has carried out an investigation with the object of ascertaining the manner of initiation and of spreading of cracks in mild steel bars, as well as measuring the stress necessary to extend an existing crack, which he refers to as the "crack strength." Stress distribution in a cracked bar under load is uneven so the "crack strength" is expressed as a mean value of stress over the remaining cross section of the bar.

The material used was mild steel, annealed at 880 deg. Cent. for thirty minutes and cooled in the furnace. Its composition and properties were as follows:—

C %	Mn %	Si %	P %	S %
0·18	0·41	0·24	0·03	0·03

Upper yield point ...	15·9 tons per square inch
Lower yield point ...	14·7 tons per square inch
Tensile strength ...	25·6 tons per square inch
Elongation on 50mm	47 per cent
Fatigue limit (rotary bending)...	14·9 tons per square inch

It is unfortunate that the notched-bar impact value is not given, to facilitate comparison with other mild steels, but judging by the behaviour of the notched and cracked tensile test piece (Fig. 1) absorption of energy in the notched-bar impact test would have been high.

Round bars, 21mm in diameter, were turned down to 17mm, a 60 deg. V-notch 1mm deep, root radius about 0·05mm, was machined all round the bar and a fine crack induced at the bottom of the notch by subjecting the specimen to a rotary bending stress of 10·2 tons per square inch (measured on the area of the bar at the bottom of the notch) at about 2500 r.p.m. After about 10^4 repetitions of stress there was a change in the note emitted by the machine indicating the initiation of a crack at the bottom of the notch. Deflection measurement were then made after every 50,000 repetitions

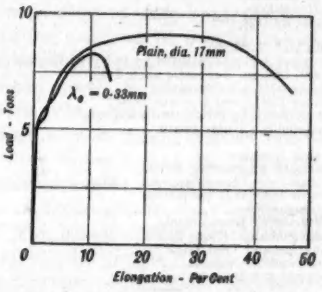


FIG. 1—*Load-Extension Curves of Plain and Round-Cracked Specimens (Isibasi)*

of stress, or at shorter intervals. From these some idea of the depth of the crack could be obtained. For a more accurate indication, the test piece was heated at 200 deg. to 250 deg. Cent. for ten to twenty minutes in an electric furnace. By such heating the initial crack was coloured light orange and its depth could subsequently be determined by measuring the coloured part after the specimen was broken. Fig. 1 shows the stress-strain diagram of a plain specimen, and that of a notched test piece with a depth of crack (λ_o) below the notch of 0·33mm. The effect of a crack on tensile rigidity was small. A crack 0·6mm deep reduced the apparent modulus of elasticity by 6 per cent. Bending tests later showed that reduction of flexural rigidity was also small if the crack was shallow. Tests made on specimens annealed at 250 deg. Cent. for twenty minutes

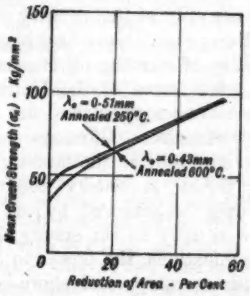


FIG. 2—*Relation between Mean "Crack Strength" and Reduction of Area at Minimum Section (Isibasi)*

to colour the initial crack, or at 600 deg. Cent. for thirty minutes to soften the hardened zone at the root of the crack, showed that the "crack strength," σ_n (tensile load divided by remaining sectional area) was about the same except in the early stage of loading, irrespective of the presence or absence of the strain-hardened layer at the base of the crack. The initial strain-hardened layer had no effect on the statical mean "crack strength," which increased in proportion to reduction of area (Fig. 2), i.e., resistance to growth of the crack increased as the crack deepened.

If P is the tensile load on the round-cracked specimen, f_o the minimum section at the beginning of the test, q the reduction of area of this section and σ_n the actual mean stress then $P=f_o\sigma_n(1-q)$. For the maximum load that the specimen can sustain, $dP=O$, or $d\sigma_n/dq=\sigma_n/(1-q)$. As soon as this condition is fulfilled the crack deepens very rapidly unless the specimen is unloaded to some extent. So long as $d\sigma_n/dq$ is greater than $\sigma_n/(1-q)$ the crack does not deepen unless the load P is increased. During the tensile tests part of the crack was projected on to photographic paper at a magnification of 27, to enable the form and dimensions of the crack to be observed. As the tensile load increased the initial crack, formed by fatigue, widened owing to the occurrence of plastic deformation at the base of the crack. Then, abruptly, a short new crack appeared at the root of the initial crack. As the load was further increased, the new crack opened wider and a second crack appeared suddenly at the root of the first. This discontinuous process persists until the load has attained a value at which the condition set out above is fulfilled. After this load is reached the formation of a new crack is accelerated and fracture ensues.

In the bending of a round-cracked bar the critical condition is expressed by $d\sigma/dk=3\sigma/(1-k)$, where σ is the bending stress and $k=2\lambda/d_o$, λ being the depth of crack and d_o the effective diameter of the specimen. If $d\sigma/dk$ is less than this value a round crack once started will spread and the specimen will fail in fatigue. If, however, there is a region of stress in which $d\sigma/dk$ is greater than $3\sigma/(1-k)$ a crack will not deepen under the stress by which it was formed, and a larger bending moment must be applied to increase its depth. Professor Isibasi believes that there is such a region, and

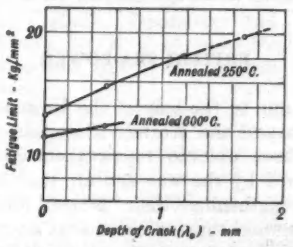


FIG. 3—*Relation between Fatigue Limits and Depth of Cracks (Isibasi)*

gives an example of a specimen which withstood over 10^7 repetitions of the load under which the initial crack had been developed.

The fatigue limit of unnotched specimens was 23·5kg per square millimetre (14·9 tons per square inch) and the endurance limit of the notched specimens for 10^7 cycles was: annealed at 250 deg. Cent., 13, and annealed at 600 deg. Cent. 11kg per square millimetre. The endurance limit increased with the initial depth of crack (Fig. 3), as did the static load. In the light of these results a warning is given that if a small crack is present in a welded member, a stress-relieving treatment at 600 deg. Cent. will lower its fatigue limit considerably.

Professor Isibasi suggests that types of fracture have a close connection with speed of deepening of the crack, and that whether a fracture turns out to be ductile or brittle will depend on the speed with which the crack penetrates the material. In this he is in agreement with Gensamer,[2] who has stated: "For each structure there is a critical crack speed upon reaching which the relatively slow and stoppable crack races away and builds up to very high speeds. When we know more about crack speed and the factors affecting it, we shall know more about how to make our structures safe under the most adverse conditions, and more about the relationship between fracture in laboratory specimens and in our structures."

[1] T. Isibasi, "Strength and Deformation of Low-Carbon Steel Bars with a Round Crack under Statical and Repeated Loads," *Memoirs of the Faculty of Engineering*, Kyushu University, 1951, Vol. 12, page 281.
[2] M. Gensamer, *Properties of Metals in Materials Engineering*, A.S.T.M. Special Publication, 1948.

SHIPYARD MODERNISATION.—The reconstruction of the Ateliers et Chantiers de France, which suffered severe war damage, is well advanced. The number of berths is being reduced by one in order to provide a lay apart space for prefabricated sections and, by next year, the yard will be able to build simultaneously three tankers of 40,000 tons deadweight while one berth is being prepared to take a tanker of 58,000 tons deadweight.

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BRITISH SEA-POWER

THANKS to the help of the United States, Britain and the Western European nations have been able to repair their economies shattered by the war and are now engaged in strengthening their armed forces for their mutual support to prevent a repetition of 1940. For Britain this means building up armies and air forces for the defence of the Elbe frontier, much larger than would normally be maintained in peace, at a time when the Royal Navy has been so reduced by the scrapping, selling and giving away of warships since the war that our naval strength is now far below the minimum hitherto regarded as essential for a first-class naval power. Moreover, we are having to build up these armies and air forces when our own safety demands that all our available shipbuilding resources should be concentrated on the construction of modern fast anti-submarine and minesweeping vessels, if we are not to starve for lack of food and raw materials. We have still a considerable number of wartime anti-submarine frigates but recent developments enable the modern submarine to proceed at a speed too fast for these wartime vessels to hunt and destroy her. Russia has upwards of 300 submarines in commission, many of which are of modern design, in addition to a very large number under construction. If war should come, we may expect submarines to be used not only for torpedoing merchant ships but also for firing guided atomically charged missiles at the centres of our population and for laying acoustic and magnetic mines. Minelaying by ships of all kinds is a form of naval warfare particularly favoured by the Russians. The new ships to be laid down under the present naval rearmament measures are in consequence limited to anti-submarine vessels. Over forty minesweepers and twenty-four fast anti-submarine vessels are being laid down and forty-five of our existing 110 destroyers are being converted into fast frigates for convoy escort duties. This new construction probably represents all we can do if we are still to continue to earn dollars by building merchant ships for South American and other foreign countries, but it would have been more satisfactory had it been started in 1948, when the number of Russian submarines was equally well known, except, apparently to the Government. It is to be completed by 1955 and one can only hope that the Government will then no longer have to admit that we could not win another Battle of the Atlantic—that we cannot, in fact, protect our sea-borne trade—without the assistance of the United States Navy.

The building programme is, however, purely defensive, since a war cannot be won by anti-submarine vessels alone. Indeed, the whole of the rearmament measures now in hand—not only of this country but of the Western European nations—are based on the practicability of warding off Russian attack until the vast forces of the United States can come to our support and are ready to take the offensive. Offensive operations across the seas require the landing of expeditionary forces in enemy territory and this can only be achieved by sea power—the power to deny to our enemy the use of sea communications, the power to deal with such hostile warships and shore-based aircraft as are likely to be encountered in enemy waters. Under modern conditions this means Task Forces, each comprising some half-a-dozen aircraft carriers with a substantial force of cruisers and destroyers to escort them. On present evidence Russia has no battleships, but ships of this type, with their powerful and concentrated anti-aircraft armament, rendered invaluable support to the aircraft carriers in Pacific operations during the last war and may well be required again for this purpose. But during the present emergency, offensive operations—the winning of a war—must be left to the United States, for the Royal Navy is in no condition to provide Task Forces of the required size. With the "Eagle" and "Ark Royal" now nearing completion and the four "Hermes" class, which have been building since the war and will all be completed by 1955, we shall have a total of only twelve carriers with the necessary speed and performance to operate the latest kinds of aircraft. And even the attainment of this small number, if they are to operate in enemy waters against shore-based aircraft, depends on the modernisation of the six existing fleet carriers of the "Illustrious" class. These ships are now being taken in hand one at a time for modernisation, which includes strengthening the flight deck and the installation of higher performance arrester gear and catapults. The cruiser position is even worse, for we have now only twenty-five of these vessels to provide support for Task Forces and to guard the many focal trade areas which may be attacked both by enemy cruisers and armed raiders disguised as peaceful merchant ships. What then is to be the future policy for our armed forces? In the long run, when the emergency is over and the French and other European armies are re-equipped and once again up to their normal peace-time strength, we shall have to choose, as Lord Strabolgi pointed out in the House of Lords, between a large army, a large air force and sea power. We cannot afford all three. And there can be no doubt what this choice should be.

The British people, who are proud of their country and of the prestige and influence she has exercised for generations through her sea power will not be prepared for ever to rely on the United States. Nor would it be safe to do so. If the United States has replaced Britain as the greatest and most powerful nation in the world, this does not necessarily mean that she will always be willing to come to our assistance at once or even to intervene at all in quarrels once the spread of Communism has been checked. We have suffered grievously from two world wars within a short period of thirty years, but we can and must again stand on our own feet by rebuilding the sea power which made this country a great nation. Atom bombs and atomic weapons, aircraft with supersonic speeds, guided missiles and other modern developments have not diminished the value of sea power. On the contrary, they have enhanced its value, for sea power enables these new weapons to be taken to where they can most effectively be used—to the vicinity of the enemy's territory. The first essential is to build up our anti-submarine forces to counter the immediate threat to our sea communications. But our ultimate goal must be a Navy which is able to take the offensive—an adequate number of carriers and cruisers—to enable this country once again to play an effective role in world affairs.

TAXATION AND DEPRECIATION

IT has long been contended by industry in this country that high rates of taxation, combined with allowances for depreciation that take no account of the cost of replacing the assets so depreciated, have been and are depleting capital resources. In opposition to that contention, the trade unions, if not indeed the Socialist Government, have maintained that the profits industry has been making since the war have been too high and that too great a proportion of those profits has been distributed to shareholders. Attempts have recently been made, notably by the British Bankers' Association, to discover the true facts. But until last week no figures were available relating solely to

manufacturing industry. Then, however, the Federation of British Industries issued a pamphlet entitled *The Effects of Inflation on Industrial Capital Resources*. It is a factual study of the financial state of some eighty large, medium and small manufacturing firms, and the main conclusion drawn is that the amount of undistributed profits put to reserve in the last few years has been inadequate to maintain industry's capital over the years. Nor has too much profit been distributed. For the proportion of profits distributed has not risen, but fallen. "It is clear, therefore," to quote from the pamphlet, "that the levels of prices and profits have not been excessive, but too low to sustain the burden of taxation under existing methods of computation and to maintain the productive capacity of industry."

This is a technical, not a financial journal, and we do not therefore intend to enter at all deeply into a discussion of the figures upon which the conclusions of the pamphlet are based. But it will be obvious that the engineering industry cannot continue to prosper, to increase its output and so to contribute to a rising standard of living in this country unless the amount of its plant is increased. Very broadly—we can afford to make broad statements when we write of a whole industry—productivity is only to be raised by an increase in fixed assets per employee. In this pamphlet the figures for the sample of eighty companies concerned show fixed assets per employee in 1938 at 1949 prices of £628, whereas the 1949 figure was only £449. It may, indeed, be suspected that some other factor, such as unemployment or the operation of plant well below capacity, may have influenced the 1938 figure. Yet it is still disturbing to find a movement apparently in the wrong direction. The factor that is the basis of the whole study in the pamphlet is that of the depreciation of capital assets and the influence of inflationary conditions in concealing what is in reality happening. If equipment were bought for £1000 in 1938 and depreciated over fifteen years, then, when its useful life was ended in 1953, the accounts would contain a sum of £1000 to be expended on replacement. Judged solely by accounting methods the capital has been preserved. But if in the meantime the cost of replacement has doubled or trebled—as, in fact, it has—the real asset can only be preserved by "ploughing back" a larger amount of profit into the accounts, an amount sufficient to replace the asset. A similar argument applies to current assets. Unfortunately, however, for taxation purposes, the excess of profit so ploughed back over and above that necessary to replace the original money value is not relieved of tax and since the level of that taxation has been running at over 40 per cent of the national income ever since the early days of the war it has, according to the figures in the pamphlet, proved impossible for firms to plough back sufficient profit. The profits retained by the eighty firms concerned fell far short of that necessary to maintain real capital intact. As the pamphlet remarks: "No business looks elsewhere for finance—for which it must pay a price in dividends or interest—if it has sufficient left of its own profits after taxation to maintain its capital." But, in fact, these eighty companies had to seek funds heavily from outside their organisations by issuing shares and borrowing money very largely to maintain existing assets, not to create new ones!

It is, of course, true that out of all the manufacturing concerns in this country eighty forms a very small sample. Yet, though a larger sample might call for a revision of the actual figures, there can be little doubt of the truth of the picture painted. The root cause of the trouble revealed is, of course, inflation. But it is also interesting to note that the high rate of taxation seems to be proving inflationary in itself. For if firms need to borrow from the banks merely to maintain capital intact, credit is being created without any corresponding increase in real assets. The further point may be made that the figures given in the pamphlet offer no support to the arguments of trade unions that profits are too high. For between 1945 and 1949 the proportion of total profits distributed fell from 27 to 22½ per cent, while the proportion undistributed rose from 14½ to 28 per cent. No doubt the F.B.I. will bring the figures revealed in the pamphlet to the notice of the Royal Commission on Taxation that is now sitting. We also understand that the Federation intends to continue the investigation so begun, bringing the figures up to date year by year and expanding the size of the sample.

Literature

Radio Installations: Their Design and Maintenance. By W. E. PANNETT, A.M.I.E.E. London: Chapman and Hall, Ltd. 37, Essex Street, W.C.2. Price 45s.

IN the mounting literature on radio this book is unusual for its wide scope. The sixteen chapters cover nearly every aspect of radio installations, as will be gathered from the following list of subjects covered: choice of a site for a receiving or transmitting station; arrangements for power supply; use of valves for rectification, amplification and oscillation; keying and modulation systems (a.m. and f.m.); valve cooling; control and protective equipment; transmission lines; receivers (a.m. and f.m.); and station maintenance and testing. Emphasis throughout the book is on practice rather than theory; in dealing with such an enormous range of subject matter the author has quite rightly decided that little space can be devoted to theoretical matter (such as negative feedback, to quote one of many examples), which are adequately treated elsewhere.

A minor criticism is the author's use of non-standard symbols, such as R_a for valve anode impedance, and non-standard terminology, such as condenser for capacitor. A more serious criticism is the treatment of frequency modulation, which, from Fig. 126, is clearly not the author's best subject. There is h.t. on the control grid of *V*1 and none of the remaining valves have d.c. returns from control grid to ground; there is no indication of the origin of the 10 Mc/s carrier and the a.f. input to the reactance modulator is applied through an r.f. transformer. The output of the reactance modulator is described as "1·8 Mc/s ±12·5 kc/s subsequently multiplied to 60 Mc/s ±75 kc/s"—presumably carried out by a multiplier capable of distinguishing between the carrier and the sidebands. This output should, of course, be 10 Mc/s ±12·5 kc/s. The text accompanying this diagram and on page 358 shows that the author is unfamiliar with the operation of the Seeley-Foster discriminator and is apparently under the impression that an f.m. transmission of ±100 kc/s deviation occupies a bandwidth of 200 kc/s. These are serious errors in an otherwise sound volume and the author would be well advised to study a textbook on f.m. before contemplating a second edition.

There are many minor errors; for example, the statement on page 368 that the steady potential across the grid resistor of a leaky grid detector is inversely proportional to carrier amplitude, and page 340, where the author claims that two voltages at different frequencies connected across a common component give rise to signals at sum and difference frequencies. This, of course, is only true of a non-linear component. It would, however, be unfair to list further errors here because, no matter how thorough the proof reading, it is impossible to eliminate them all from a first edition.

On the whole, the book covers its wide field competently and should prove extremely useful to maintenance engineers at transmitting and receiving stations.

Advanced Fluid Dynamics and Fluid Machinery. By R. C. BINDER. New York: Prentice-Hall, Inc. 70 Fifth Avenue. Price 8 dollars.

THIS book is an extension of the same author's "Fluid Mechanics," and is intended to bridge the gap between the usual first treatment of the subject and the more advanced problems found in engineering practice. It is divided into three parts: Part I is on engineering fluid mechanics including one-dimensional compressible flow, fluid friction and the boundary layer; Part II deals with machinery such as fans, pumps, turbines and compressors; and Part III considers more complicated cases of compressible flow, and includes chapters on the equations of motion and other material usually found in textbooks of mathematical hydrodynamics.

The book is written throughout for engineers, and although introducing mathematics keeps them wholly as tools and not as excuses for demonstrating elegant methods. In contrast with other textbooks, the proofs and details of streamline plotting in perfect fluids, so frequently a subject of difficulty to undergraduates, is left until Part III. The text is an example of how technical books should be written in English, complicated sentences and phrases being avoided, and the utmost clarity has been achieved. The references at the end of each chapter are nearly all American, and the diagrams are impeccable.

This book is likely to become popular in spite of its high cost, on account of the lucid way in which the author has explained the fundamentals of the subject. It is to be recommended as a textbook for final year university students and as a valuable reference book for practising engineers.

BOOKS RECEIVED

Stereoptics. By Leslie P. Dudley. London: MacDonald and Co. (Publishers), Ltd., 16, Maddox Street, London, W.1. Price 15s.

Applied Mechanics for Engineers. By Sir Charles Inglis. London: Cambridge University Press, 200, Euston Road, N.W.1. Price 42s.

Sheet Metal Shop Practice. By Leroy F. Bruce. London: Technical Press, Ltd., Gloucester Road, Kingston Hill, Surrey. Price 32s.

Fundamentals of Automatic Control. By G. H. Farrington. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 30s.

In the Workshop. Vol. III. By "Duplex." London: Percival Marshall and Co., Ltd., 23, Great Queen Street, W.C.2. Price 9s. 6d.

Obituary

A. L. MELLANBY

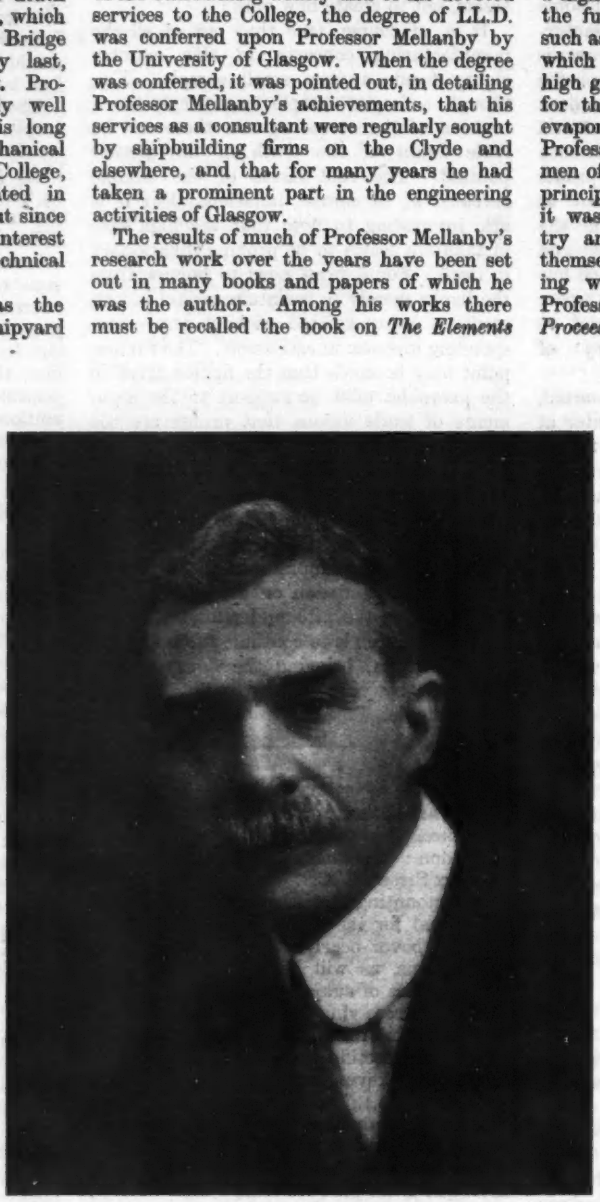
THE engineering profession has lost one of its distinguished members by the death of Emeritus Professor A. L. Mellanby, which occurred at his home at Westwood, Bridge of Weir, Renfrewshire, on Monday last, November 26th, at the age of eighty. Professor Mellanby will be particularly well remembered by his work during his long tenure of the Chair of Civil and Mechanical Engineering at the Royal Technical College, Glasgow, to which he was appointed in October, 1905 He retired in 1936, but since then had continued to take a keen interest in the work of the College and in technical education in general.

Alexander Lawson Mellanby was the son of the late Mr. John Mellanby, a shipyard manager of West Hartlepool. He was born on July 3, 1871, and received his general education at the North-Eastern County School, Barnard Castle. At the age of sixteen, he began an apprenticeship in the Central Marine Engine Works, Newcastle upon Tyne, and on its completion in July, 1892, remained there for some months as a draughtsman. Later, in 1892, Mellanby entered the Durham College of Science, Newcastle upon Tyne, where he obtained his B.Sc. degree with honours, and also gained an 1851 research scholarship. He then proceeded, in 1895, to McGill University, Montreal, and for the next year or so was engaged in research work on multiple expansion engines. Mellanby returned to this country towards the end of 1896 and continued at the Durham College of Science the research work which he had started in Canada.

In July, 1897, Mellanby was appointed chief technical assistant in the Hartlepool works of Richardsons, Westgarth and Co., Ltd., or T. Richardson and Sons, as the firm was then entitled. He continued in that appointment —the only one which he held with a commercial firm—until October, 1898, when he came to London as chief lecturer in engineering at the Battersea Polytechnic. That appointment marked the beginning of Mellanby's long and successful career in the engineering teaching profession. He remained at the Battersea Polytechnic for a year and was then invited to assist the late Professor J. T. Nicolson in designing and equipping the laboratories, workshops and power station at the Manchester College of Technology. This work subsequently led, in October, 1901, to his being appointed Lecturer in Engineering at the College.

Mellanby's stay at the Manchester College of Technology lasted for four years, and in October, 1905, he was appointed to the Chair of Mechanical Engineering at the Royal Technical College, Glasgow. It was the beginning of a long and valuable period of service, and under Professor Mellanby's wise and able guidance, his department of the College was raised to a very high state of excellance. On the death of Professor J. G. Longbottom in 1924, Mellanby was selected to take complete charge of the Department of Civil and Mechanical Engineering and applied mechanics, which position he held until he reached the age of retirement in 1936. In June of that year, in recognition of his outstanding ability and of his devoted services to the College, the degree of LL.D. was conferred upon Professor Mellanby by the University of Glasgow. When the degree was conferred, it was pointed out, in detailing Professor Mellanby's achievements, that his services as a consultant were regularly sought by shipbuilding firms on the Clyde and elsewhere, and that for many years he had taken a prominent part in the engineering activities of Glasgow.

The results of much of Professor Mellanby's research work over the years have been set out in many books and papers of which he was the author. Among his works there must be recalled the book on *The Elements of Machine Design*, in the preparation of which he collaborated with the late Professor W. Cawthorne Unwin. Then there was a series of papers dealing with various aspects of steam turbine troubles, which, in company with Professor William Kerr, Mellanby presented to the North-East Coast Institution of Engineers and Shipbuilders. Another work in which Professor Mellanby took a leading part was in the preparation of an English translation of *Materials and Design in Turbo-Generator Plant*, by Dr. O. Lasche. In that task, Mr. W. Roylands Cooper assisted Professor Mellanby.



A. L. MELLANBY

As might be expected, Dr. Mellanby made valuable contributions to the work of many learned societies in this country. Reference has already been made to some of his contributions to the North-East Coast Institution of Engineers and Shipbuilders, of which he was a member. In 1937, he was invited to deliver the Andrew Laing Lecture to that Institution, and in it he dealt very effectively with the subject of land and marine boilers. In the course of his lecture, Professor Mellanby spoke of light-weight boilers with a high rate of heat transmission and recalled the fundamental work of British scientists, such as Osborne Reynolds and J. T. Nicolson, which had made possible the proper use of high gas speeds and forced water circulation for the attainment of very high rates of evaporation. In his characteristic manner, Professor Mellanby appealed to the younger men of the day to recognise that if some new principle was ever brought to them, then it was their duty to investigate it and to try and put it into an engineering form themselves, and not to allow all the pioneering work to be done by other nations. Professor Mellanby also contributed to the *Proceedings of the Institution of Engineers and Shipbuilders in Scotland*, the Manchester Association of Engineers, and to the Royal Society of Canada to which he presented a paper on "The Relative Efficiencies of Multiple Expansion Engines."

Special mention must be made of Mellanby's long association with and service to the Institution of Mechanical Engineers, to the membership of which he was elected in 1906. For some years he served on the council of the Institution and represented it on the joint committee for national certificates in engineering in Scotland. He was also a member of the Marine Oil Engine Trials Committee. Professor Mellanby was elected to honorary life membership of the Institution in 1940, in recognition of his eminent scientific attainments. In the same year he delivered the Thomas Lowe Gray Lecture to the Institution. It was appropriately entitled "Fifty Years of Marine Engineering," and was, in fact, a comprehensive survey of much of the work with which Mellanby himself had been associated. In the lecture he again affirmed his opinion that most of the improvements in engineering practice had sprung from the application of scientific principles to design and manufacture, and that to a great and often unappreciated extent both experimental and analytical research had contributed to the initiation and appreciation of those principles. But, Mellanby added, often owing to the long time that had elapsed between the discovery and the application of some new principle, the origin of the idea and the identity of the discoverer had become obscure and the credit for any advance had frequently been given to him who had had the quickness of vision necessary to see the value of the application!

G. H. BAILLIE

WE record with deep regret the death of Mr. Granville Hugh Baillie, which occurred at The Thatches, Letchworth, on November 19th. He was seventy-eight, and for a long period had been actively associated with the work of the British Tabulating Machine Company, Ltd., of which he became a director in 1910.

Granville Hugh Baillie, who was the son

of the late Mr. William Montague Baillie, was born at Bath in 1873. His early education was received at Mr. John's private preparatory school at Winchester, the intention being that he should proceed to Winchester College. Unfortunately, however, Baillie contracted rheumatic fever and his education had to be continued privately. But later he gained a degree at London University and then took a post-graduate course in engineering at the Zurich Polytechnic. Mr. Baillie's first important position—as a young man of twenty-five—was to take charge of the installation and running of the generating station and electric lighting and tramway systems at Bordighera, Italy. He subsequently returned to England to join Sir James Swinburne in a consulting engineering practice. Later, Mr. Mervyn O'Gorman joined the partnership which operated for some years in Westminster under the style of Swinburne, O'Gorman and Baillie.

When the partnership was dissolved, Mr. Baillie became associated with Mr. Dobree, specialising in patent development. He frequently appeared in the courts as an expert witness, and it was in that capacity that he used the first cinema film ever shown as evidence in the High Court. During the first world war, Mr. Baillie worked at the Ministry of Munitions, under Sir Stephenson Kent, and dealt very ably with the numerous problems concerned with the dilution of labour. For his services during the war—which included a special mission to the U.S.A. in 1916—he was awarded the O.B.E. Mr. Baillie was a director of several engineering and allied companies, including Aero Engineering, Ltd., P.I.V. Gears, Ltd., and Macrome, Ltd. When the second world war came he added to his responsibilities by becoming a joint managing director of the British Tabulating Machine Company, Ltd.

Mr. Baillie was an able motorist and owned his first car about the beginning of this century. It is of interest to recall in this connection that when it became compulsory to carry number plates he obtained the No. 1 for Aberdeen—S.T.1—which he retained until 1940, the number being transferred from car to car during the intervening years. Mr. Baillie was a vice-president of the Royal Automobile Club, and for many years was a judge at all its official trials.

But Mr. Baillie was not only a capable engineer and good business man. In his own workshop he produced, by his expert craftsmanship, much beautiful work in metal, ivory and rare woods. He was also a great authority on old clocks and watches and was the author of a standard work on the subject, as well as a complete list of all clock and watchmakers up to the middle of the nineteenth century. It may be recalled that Mr. Baillie took an enthusiastic part in the arrangement, by the Clockmakers' Company of London, of the exhibition showing the history of time measurement, which was held at Guildhall during the summer and an account of which was included in our issue of July 13th.

W. H. BALLANTYNE

We have learned with regret of the death of Mr. William Henry Ballantyne, of Vine Cottage, Sevenoaks, which occurred, on November 19th, following a street accident at Eastbourne.

Mr. Ballantyne, who was seventy, was educated at Allen Glen's School, Glasgow, and graduated in engineering at Glasgow University in 1900. In the same year he joined the firm of Messrs. Boult, Wade and Tennant, chartered patent agents, of which he was senior partner at the time of his death. For many years he practised as an expert witness in legal actions involving patents.

Mr. Ballantyne was a Fellow of the Chartered Institute of Patent Agents (being president in 1938), a Fellow of the Royal Institute of Chemistry, and a member of a number of other scientific societies, including the Chemical Society, the Society of Chemical Industry, the Faraday Society, the Royal Institution, the British Association for the Advancement of Science, and the Junior Institution of Engineers. For many years he was secretary of the British group of the International Association for the Protection of Industrial Property.

He took a keen interest in civic affairs in Sevenoaks, and for some years was a member of the Urban District Council, becoming chairman in 1935. During the first world war, Mr. Ballantyne served with the Warwickshire Regiment in the Middle East and in India, and attained the rank of Major, and in the second world war he was a gas identification officer for Holborn and for Sevenoaks.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ASSESSMENT OF LOCOMOTIVE PERFORMANCE

Sir,—Now that it has been established that the down "Coronation" was a good time-keeper, even on the most exacting part of the schedule to York, some other reason must be advanced to explain what from the figures appears to be an excessively high sustained power output. In applying the Johansen formula for train resistance, Dr. Tuplin may have introduced errors with the streamlined stock, in view of the articulation and the fairings between and under the coaches, not forgetting the "beaver tail," although the latter was only carried during the summer. The effect of these is hard to judge, but when they are not considered the power output of the locomotive will naturally be assessed at a higher figure than is actually the case.

In addition, at 70 m.p.h., the saving in horsepower due to the streamlining of the A4 "Pacifics" has been quoted as 65. Although the work of moving the locomotive through the air is normally excluded from any calculation of the drawbar horsepower, any saving due to the streamlining will naturally appear as gain at the drawbar. Assuming then that the average saving over the journey due to the streamlining is as quoted above (a conservative figure in view of the square resistance law), this will reduce the average power output for the locomotive of the down "Coronation" to approximately 30 d.h.p. per square foot of grate area: a more reasonable figure and one that is compatible with the good time-keeping of the train.

P. W. B. Semmens

Middlesbrough, Yorks, November 19th.

Sir,—Dr. Tuplin's original statement was that the "Coronation" schedule was "a shade too tight" (page 453, October 12, 1951), but in his reply to my comment on this he modified it to "somewhat tight." "A shade too tight" implies that net times of 158–161 minutes are to be anticipated, but "somewhat tight" that time can be kept with an effort, and from the latter proposition I should not dissent.

I estimate that the maximum effort needed between King's Cross and York (in the turning of Stoke summit) entailed about 2660 i.h.p., while at one or two other points an output not far short of this figure was required. Now the maximum sustained capacity of a standard A.4 is (or rather was) just over 2600 i.h.p., and it is thus very likely that the engine would need to be worked "all out" for a short time at at least one point on the journey. This is a measure of the strenuous nature of the schedule.

Most of the runs which I cited were made after the restriction to 70 m.p.h. between York and Darlington had been removed and the schedule between York and Newcastle modified, and Dr. Tuplin is thus quite correct in pointing out that no reliable deductions as to arrival times at York can be made from observed times at Newcastle. Maintenance of 90 m.p.h. on the level would be the limit of A.4 capacity.

Direct evidence alone can permit of a valid evaluation of the point at issue and I should be very interested to know on what evidence Dr. Tuplin based his original assertion. It is, however, rather unlikely that a fair sample of adequate records could be collated at this stage, through sheer lack of documentation, and the question may therefore well remain unsettled.

J. D. Mannion

Chelmsford, November 16th.

THE INDUSTRIAL REVOLUTION

Sir,—Mr. A. Kerr's reference in the current issue to the construction of the Pyramids raises the interesting question as to whether these were built by "private enterprise" or "nationalised labour." It would seem that Kipling entertained no doubt about this when he wrote:—

> "Who shall doubt the Secret hid
> Under Cheops' Pyramid?
> Was that the contractor did
> Cheops out of several millions!"

November 23rd. A. R. V.

ENGINEERS OR ARCHITECTS

Sir,—The controversy between Mr. Chalmers and Messrs. Knighton and Evans in your recent issues is not one on which I wish to express an opinion. I am aware that the subject of it has cropped up on various occasions. It is one that would be and should be settled by a committee of a tribunal set up by a federation of the professions, which is still not organised, but which was advocated by Sidney Webb (Lord Passfield) long ago.

The trades unions were organised long ago on such a basis and settle disputes between their component bodies by their elected councils.

The United Nations Organisation has set a pattern for the whole world by resolving differences between the nations of the world, and I have no doubt that the time is approaching when all professions, crafts, political and economic questions, will be settled and reviewed from time to time and that the common status of mankind will be established.

In this way the greatest principles that the world has ever known, revealed 2000 years ago, will come into general operation.

A. W. Crampton, F.R.I.C.S.

Hampstead, N.W.6, November 22nd.

A Solder for Electrical Connections.—A liquid activated resin-based flux called "Telecene," has been developed by H. J. Enthoven and Sons, Ltd., 89, Upper Thames Street, London, E.C.4, to provide a rapid working and effective flux for use in electrical engineering, especially those soldering operations in which it is preferable to use a solid solder wire rather than a rosin-cored solder. "Telecene" consists of high-quality rosin dissolved in methylated spirit and contains an activating agent similar to that incorporated in the popular "Superspeed White Flash" activated rosin-cored solder produced by the same company. The activating agent gives the rosin a much more vigorous fluxing action. It is particularly suitable for mass dip-soldering operations such as electric motor and dynamo armature commutator connections. Other uses are in fluxing before pretinning the radial contacts of selector and uniselector multiple banks.

Agricultural Machinery Exhibition at Earls Court

No. I

ON Monday next, December 3rd, there will open at Earls Court, London, the third Smithfield Show and Agricultural Machinery Exhibition to be held since the war. It will continue, from 10 a.m. till 9 p.m. daily, until Friday next, December 7th. The "Smithfield" has a long and distinguished history dating back to 1799, when the first show of the Smithfield Club was held. In earlier years, of course, it was devoted almost entirely to cattle, and was indeed a market of considerable importance to farmers, cattle dealers and meat traders. For a long period the show was staged annually at the Royal Agricultural Hall at Islington, and as time passed there was an increasing quantity of agricultural machinery and implements to be seen in addition to the livestock.

The second world war caused a break in this long succession of exhibitions, and it was not possible for the show to be revived until 1949, when a joint committee representing the Smithfield Club, the Agricultural Engineers' Association, and the Society of Motor Manufacturers and Traders became responsible for the organisation, and Earls Court was selected as a suitable building in which to present the exhibition in its post-war form. The livestock and carcase entries and competitions continue to be a most attractive item in the programme and continue to hold an important place in the show, but the rapid progress in agricultural mechanisation over the last decade has naturally led to a tremendous increase in the number and variety of implements and machines exhibited compared with pre-war years. The present "Smithfield," therefore, is an exhibition of great interest to engineers as well as to farmers and butchers. It is the only large exhibition of agricultural machinery held annually in London, and it is one that is visited by many overseas buyers. Much of the machinery which will be on view at Earls Court next week was, naturally, displayed at the Royal Show and the many county agricultural shows held in the open air during the summer, but on several stands there will be discovered new productions and improvements to existing equipment which will demonstrate that the engineering and automobile industries are continuing their efforts to maintain the high technical standard of British agricultural machinery. It is also of interest to note the international character of the show, for at least twenty firms from overseas are included in the list of over 350 exhibitors in the machinery and equipment sections.

In this article we deal with two of the new tractors designed and constructed by British firms, which will make their first public appearance at Earls Court. One of them is the "New Fordson Major," which is illustrated in Fig. 1 and which is now being put into full production by the Ford Motor Company, Ltd., Dagenham, Essex. The original "Fordson Major" was introduced by the company in 1945, and, in many respects, the design of the new tractor is very similar. But the "New Major" has rather more refinements than its predecessor and indicates in a number of ways that, whilst drawing upon their valuable past experience, the makers have kept in mind up-to-date engineering techniques and also the widening field of mechanised agriculture.

The "New Major" offers a choice of three engines—diesel, petrol and vaporising oil—all of which have been designed specifically for farm work by the Ford Motor Company, Ltd. In each engine use has been made of components which are common to all three, thereby simplifying service and keeping the cost of spares low. The engines are four-cylinder, overhead valve units with replaceable wet cylinder liners and forced feed lubrication. The petrol and vaporising oil engines are governed centrifugally and the diesel engine pneumatically, over a speed range of 400 to 1700 r.p.m. In all three engines the cylinders have a bore of 100mm with a stroke of 115mm. In the diesel version a flat roof to the combustion head gives the necessary increased compression. The five-ring aluminium pistons are recessed at the top, forming, with the cylinder head, conveniently shaped combustion chambers into which the fuel is injected through four-hole nozzles. The fuel is drawn from the 15-gallon tank through a sediment bulb by a standard diaphragm fuel pump, which, incidentally, is identical with the pump fitted to the petrol and vaporising oil engines. From the pump the fuel passes through a paper element micronic filter and then to a final gauze filter incorporated in the injector pump body. The injection pump meters the fuel oil under direct pressure to the injectors, leakage from the

FIG. 1—"NEW FORDSON MAJOR"—FORD

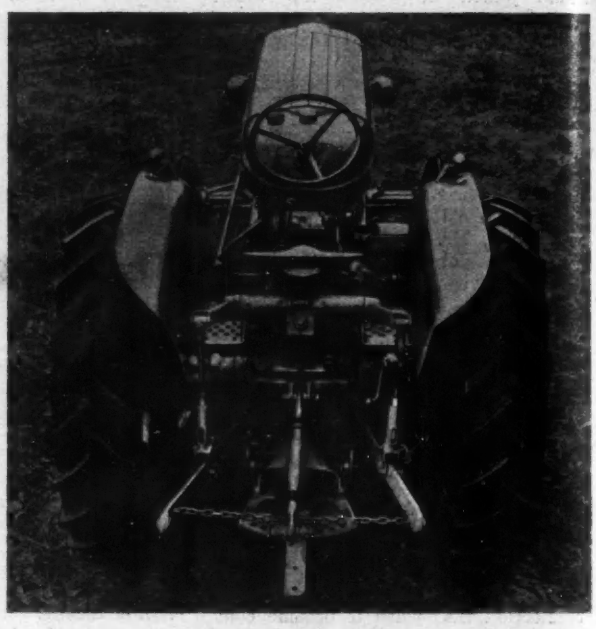


FIG. 2—TRACTOR HYDRAULIC EQUIPMENT—FORD

FIG. 3—"CHALLENGER 1" DIESEL CRAWLER TRACTOR—MARSHALL-FOWLER

injectors being returned to the fuel tank. In the vaporising oil engine a special cylinder head provides the larger combustion space and lower compression ratio which are required. An interesting point about this engine is that the change-over from petrol to vaporising oil is effected by a control on the instrument panel. Separate carburettors are fitted for petrol and vaporising oil, thus obviating the need to drain the float chamber. On all three engines the engine coolant is thermostatically controlled, radiator shutters, which are operated from the tractor seat, ensuring that the correct operating temperature is maintained.

The transmission system of the new tractor provides for six forward speeds, ranging from 2·07 m.p.h. to 13·16 m.p.h. when the engine is running at 1600 r.p.m., and two reverse speeds of 5·03 m.p.h. and 2·80 m.p.h. Power is transmitted through an 11in diameter, single dry plate clutch to the gearbox, through the crown wheel and pinion to the final drive. The clutch, which has a large friction area and nine pressure springs, is operated conventionally by the left foot. On the driver's right hand there are two brakes which can be used independently for turning, locked together for road work, or secured for parking. Twin gear levers are used, the primary lever giving a high and low ratio and the main lever giving four positions—three forward and one reverse. Once the driver has selected high or low ratio, therefore, gear changing is simplified to four positions. The power take-off is fitted with a centrally placed 1¾in diameter, six-splined shaft. Its speed is 542 r.p.m. when the engine is running at 1200 r.p.m. As may be seen in Fig. 1, a two-speed belt pulley is provided at the right-hand side of the transmission housing. The pulley diameter is 8·5in and with the engine

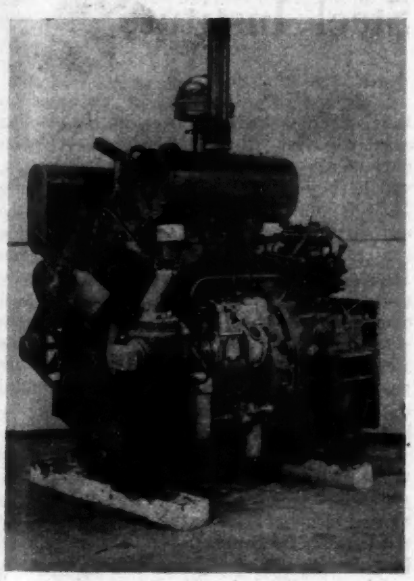


FIG. 4—50 B.H.P. DIESEL ENGINE —MARSHALL FOWLER

running at 1400 r.p.m., the belt speeds are 3115ft and 1734ft per minute for standard and slow speeds respectively.

The hydraulic arrangements of the tractor include a gear pump situated in the rear transmission housing and driven by the power take-off shaft. As the pump uses the rear transmission oil, an adequate reservoir is assured for implements employing hydraulic jacks, as, for example, hydraulically operated tipping trailers. The control lever for the hydraulic system is near to the driver's right hand and mounted implements can be raised, lowered or held at any intermediate position. When the lifting cycle is complete the lever returns to the neutral position. In the lowered position, implements are free to float vertically and independently of the back of the tractor. The photograph reproduced in Fig. 2 shows the hydraulic arrangements of the new tractor, including a simplified three-point linkage which can be adjusted to suit a variety of mounted implements. The two lifting rods can be fixed for implements with one depth wheel such as ploughs, or made telescopic for implements with two depth wheels. The top link can be adjusted in length to vary the pitch of mounted implements, and a levelling box on the offside lifting rod can be adjusted to control the lateral level of the implements. If desired, instead of the normal telescopic top link, a hydraulic safety release top link can be fitted which disengages the clutch should an implement hit an obstruction.

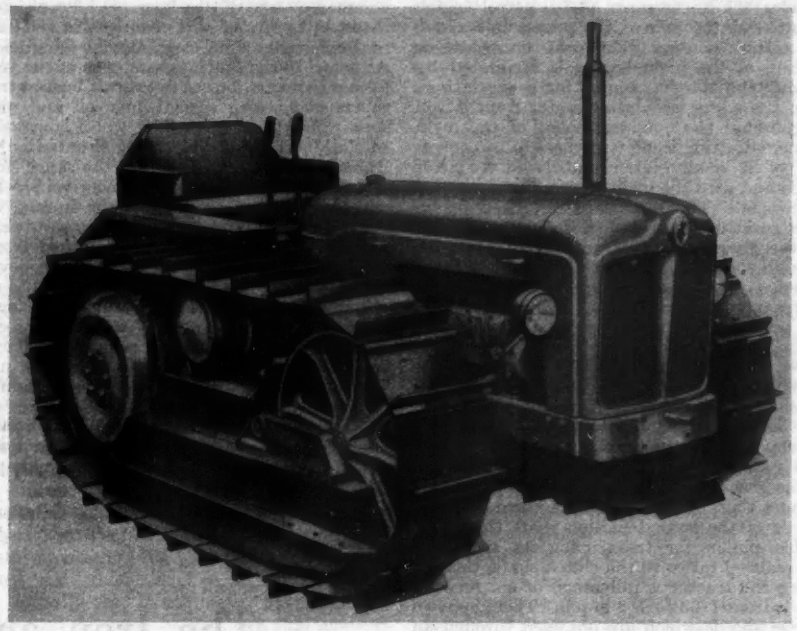


FIG. 5—"NEW FORDSON MAJOR" WITH "COUNTY" FULL TRACKS—FORD

On the standard model of the "New Major" the front wheels are fitted with 6·00×19 pneumatic tyres and the rear wheels with 11·00×36 pneumatics, both front and rear tracks being adjustable for rowcrop work. The front track is adjustable in 4in steps from 49½in to 73½in with the standard wheel equipment, and the rear track from 52in to 72in. The recirculatory ball steering gear ensure easy and positive control of the tractor, the steering lock providing a turning radius of 13ft without the use of steering brakes. With steering brakes, the turning radius is reduced to 10ft 6in.

Like its predecessor, the "New Major" can be equipped with "County" full tracks or "Roadless" half tracks. With the full tracks, as illustrated in Fig. 5, the tractor will handle four to six-furrow ploughs and similar heavy implements. Steering is by two hand levers operating independent clutches, assisted by independent foot brakes. The full track conversion is made by County Commercial Cars, Ltd., Fleet, Hampshire. The half-track equipment, which is manufactured by Roadless Traction, Ltd., is driven by sprockets fitted in place of the rear wheels, and as the idlers are fitted behind the drive sprockets the track is driven in compression. It should be added that the half track can be replaced by pneumatic tyres with the minimum trouble.

The Ford Motor Company, Ltd., has published some particulars about the performance of the new tractor. Tests which have been made with the standard wheeled tractor fitted with a diesel engine, have shown it to be capable of developing 32·8 belt horsepower at an engine speed of 1400 r.p.m. and 35·8 belt horsepower with the engine running at 1600 r.p.m. With an engine speed of 1600 r.p.m., 29·75 drawbar horsepower was developed at a tractor speed of 3·40 m.p.h.

Another new tractor which will be shown at next week's exhibition is the "Challenger I" diesel crawler which has been designed and built by John Fowler and Co. (Leeds), Ltd., Hunslet, Leeds. It will be recalled that last year this firm produced the "Challenger" Mark III crawler tractor, a machine which develops 95 b.h.p. and which is intended mainly for land reclamation and clearance projects. That tractor was described and illustrated in our issue of December 15, 1950. The "Challenger I," a general view of which is reproduced in Fig. 3, is the result of several years of development work and is intended primarily for the agricultural market, although, as the makers explain, it is well suited to industrial work of various kinds.

The power unit, which is illustrated in Fig. 4, is a twin-cylinder, vertical, two-stroke cycle diesel engine manufactured by Marshall, Sons and Co., Ltd., of Gainsborough, with which firm John Fowler and Co. (Leeds), Ltd., is associated. The bore is 5½in and the stroke 6in, giving a swept volume of 260 cubic inches. Scavenge is facilitated by a Rootes blower, supplied by Sir George Godfrey and Partners, Ltd., and the mean pressure of the air supply is approximately 3·5 lb per square inch. At 1250 r.p.m. the engine is capable of producing 50 b.h.p. and providing 43·5 h.p. at the drawbar. The cylinder block is made of high-duty iron with separate cylinder heads in similar material. A crankshaft with two throws at 180 deg. runs in three main bearings, having Glacier steel-backed, copper-lead, thin metal linings, and similar bearings are fitted to the large ends of the connecting-rods having four bolt caps, whilst the small ends have needle roller bearings. The cylinder heads each contain a central pre-combustion chamber, a decompression valve and a fuel injector. C.A.V. injection equipment is provided, the pump being chain driven from the crankshaft. A mechanical variable-speed governor is attached to the pump providing smooth and steady idling at 350 r.p.m. and governed speed up to 1375 r.p.m. The coolant is circulated by a centrifugal pump mounted on the fan spindle, delivering to the cylinder jacket, below the exhaust ports. After circulating round the cylinders, the coolant passes through four large diameter transfer holes into each cylinder head and thence by a manifold to the radiator. The fan and water pump unit is driven by twin vee belts, belt tension being adjustable by the jockey pulley.

Lubrication to the main bearings, large ends, &c., is by a gear pump submerged in the sump. A pressure-relief valve controls the main oil pressure, and the by-pass from this unit is delivered into the timing case for lubrication of the ancillary chain drives, after which it

drains back into the sump. The oil is filtered by a removable gauze filter in the sump, further filtration being given by a metal element filter with cleaning blade and a replaceable element filter. The timing gear drives are very accessible at the front end of the engine; the blower is driven by a duplex chain, a second duplex chain driving the fuel pump and lubricating oil pump, both chains having jockey tensioners. The engine is started by an opposed twin-cylinder 5 h.p. Coventry Victor petrol engine mounted at the rear of the power unit above the clutch housing. In cold temperatures starting of the main engine is facilitated by running the starting engine for a short time, when the warm circulating water from it will pass around the cylinder jacket of the main engine. Starting is effected through the operation of a small clutch and Bendix starter pinion and with the main engine decompression valve open. The 14in Borg and Beck single-plate main engine clutch is mounted directly on the flywheel which transmits the drive through a propeller shaft to the gearbox bevel pinion.

The power is transmitted by the clutch to the propeller shaft carrying the input bevel pinion, which, in turn, engages with the bevel wheel on the first motion shaft placed transversely in the casing. The shaft carries three pinions of progressively varying sizes which can be directly meshed with mating gears, thereby giving a choice of three reduced speeds to the second motion shaft. A locking device on the gear-shift lever prevents any possibility of more than one gear being engaged. In the middle of the second motion shaft there is a double pinion for transferring its speeds in two reduced ratios to the clutch shaft, thereby giving the tractor a full range of six forward speeds from 1·68 to 7·2 m.p.h. There are two reverse speeds which are obtained through an intermediary bobbin gear connecting the first and second motion shafts, causing the latter to rotate in the opposite direction to that produced with direct meshing between the two shafts. This change-speed section of the transmission is a self-contained unit mounted in an oil-tight casing with its short transverse shafts running on ball bearings. From this unit the drive to the right-hand or left-hand track driving sprocket is identical, with most of the details interchangeable. At each end of the clutch shaft there is fixed a clutch centre with external serrations which engage with the internal serrations on the metal clutch plates, and nipped between these plates, by a spring-loaded clamp plate, are externally serrated fabric discs designed to engage in the internal serration of the combined driven member and brake drum. To disengage the clamp plate and free the clutch, a cam mechanism is employed, the springs being compressed by the rotation of a cam lever which has a triple-cam face abutting on to three rollers located in a fixed bracket. Braking is by a contracting flexible steel band, covered with friction lining, operating on the outside of the clutch-driven member. The casings around the clutch and brake units keep the compartments free from the ingress of oil. The driven member is fixed to the shaft carrying the final drive pinion which engages with the final drive wheel to rotate the axle carrying the sprocket hubs. The shafts are mounted on ball bearings and the units are made oil-tight and are effectively sealed against dirt penetrating into the compartments by a spring-loaded diaphragm face seal on the sprocket hubs. The engine and transmission casings form a strong chassis which is built independently to the track unit and is easily accessible. The controls form an integral part of the chassis and consist of a gear selector, high-low range lever, two steering levers (one each side), a clutch pedal and compensated brake pedal (which can be locked for parking purposes), all of which are conveniently placed. When a slow turn is required the drive is de-clutched by operating the steering lever for half its movement, but the brake can be instantly applied, giving a sharp turn, by applying full movement of the steering lever.

The two independent track frames are coupled together at the rear by a large diameter cross beam on which they swivel, and the front ends are coupled by a double-cranked axle, the crank being forward of the axle at one side and behind the axle at the other, forming a Z-bar. By oscillating the cranked axle the track frames are given an opposite motion upwards or downwards at the front end, with the back end swivelling on the cross beam, an arrangement which holds the frames in alignment and prevents them from heeling and toeing, thereby, it is claimed, eliminating a common cause of track wear. Provision is made on the frame side channels for the fixing of implements and earth-moving equipment. Attached to the under side of each of the track frames there are four centre thrust bushed track rollers fitted with special duty oil and water seals. The front track idler wheel is arranged to slide horizontally in guides situated on the frames and is spanned by the idler fork. Between this and the cross beam swivel bracket, which is fixed to the rear of the frames, is a recoil spring mounted in a grease-packed tubular cover; the shock from any frontal blow on the idler is cushioned by this device, which also allows the idler to recoil should any obstruction be trapped between the inside of the track and passed round the driving sprocket or the idler wheel, thus preventing uncontrolled loads being applied to the track unit. The oscillations of the cranked axle are damped by two leaf springs, one mounted on each side of the transmission unit; they also control the movement of the crank throw. The tracks are of the pin and bush type, with links, pins and bushes specially heat-treated to resist wear, while there are two master track pins each side to assist servicing. The track plates are of rolled section and can be fitted with a quick spring attachment and release street plate.

Provision has been made in designing the "Challenger I" for taking off four drives for operating auxiliary equipment. At the front of the crankshaft, a drive may be taken through a resilient coupling for operating hydraulic pumps for bulldozers or carried agricultural implements; additionally a chain sprocket may be mounted on the crankshaft fan pulley. Both these drives run at engine speed. A side drive is arranged on the first motion shaft of the transmission and operates at a speed of 686 r.p.m. with the engine at governed speed, where full engine power can be absorbed. The rear power take-off, which will transmit full engine power, has a non-running position and a high and low running gear giving speeds of 1250 and 535 r.p.m. respectively. The front two power take-offs are continuously run, whereas the side and rear power take-offs can be disconnected by disengaging the engine clutch. A belt drive can be provided for coupling to the rear power take-off and has a running speed of 1062 r.p.m., the drum being 12in diameter.

The weight of this tractor in working order is approximately 10,900 lb, the overall length being 10ft 4½in and width 6ft. The gauge, from centre to centre of tracks, is 4ft 8in, and each track makes a ground contact of 5ft 0½in.

(To be continued)

The Iron and Steel Institute

No. I

THE autumn meeting of the Iron and Steel Institute was held last Wednesday and Thursday, November 21 and 22, 1951, at 4, Grosvenor Gardens, London, S.W.1.

Opening of the Meeting

The president (Mr. Richard Mather): On the 12th of next month there will be a symposium on the "Corrosion of Buried Metals." The number of those who have already promised to attend is approximately 300. That symposium, because of the numbers attending, cannot be held in these rooms and will be held in the rooms of the Institution of Electrical Engineers. I am very glad to say that Sir Charles Goodeve has consented to preside over that meeting.

I should like to refer very briefly to the meeting which the Institute held in Austria in September. Those who were there will agree that it was one of our most pleasant functions. You will be pleased to hear that, in accordance with a decision of the council shortly before the Austrian meeting, I was able to announce in Austria, at the main reception, that Dr. Oberegger, the president of the Austrian Institute and the chairman of the Reception Committee, had been elected by the council an honorary vice-president of this Institute. That announcement, which I was very glad personally to have the privilege of making, was received very warmly indeed, both by Dr. Oberegger and by our Austrian friends. We all found that Dr. Oberegger was not only a first-rate man at his job, but a most friendly, helpful and approachable person, and we feel that it is a distinct addition to the quality of our council to be able to bring him in touch with us in that way.

Most of you will have noticed that the state of war with Germany was declared to be at an end by Order in Council on July 9, 1951. The council resolved, at its meeting shortly after that date, that German nationals are now again eligible for election, which they have not been, of course, since 1939, for membership of our Institute in the ordinary way. We have discussed the arrangements for this with the Verein Deutscher Eisenhuttenleute and have mutually agreed to resume the reciprocal arrangements which were in force before the war. Details will be published in the December issue of the *Journal*. In line with that policy, the secretary last week attended a meeting of the Verein Deutscher Eisenhuttenleute in Dusseldorf.

I think that this is a proper occasion on which to let you know that the council yesterday decided to put forward to the annual meeting next spring the proposal that Captain H. Leighton Davies, C.B.E., should become the next president of this Institute.

I have one more matter to mention and it is of an unusual nature. Mr. Elsdon, the librarian of the Institute, is retiring at the end of next month after forty-eight and a half years of service with the Institute. Mr. Elsdon's work has been very conspicuous in really forming the library in the first instance and building it up until we now have a library which, as far as we can judge, is equal to the best library that has been formed by any of our corresponding Institutes anywhere. It has been Mr. Elsdon's life work and I must say that there are many of us who could envy him in being able to look back and say: "There is something which I have done which is of immense value not only to my contemporaries but also to those who will come afterwards as members of the Institute." The council has arranged that in the New Year Mr. Chattin, the assistant secretary, will take charge of the library, and that Mr. Post, who joined our staff a few years ago, will become joint

assistant secretary. I am confident that these arrangements will work well.

There followed a joint discussion on the following papers :—

THE CRYSTAL STRUCTURE OF GRAPHITE IN CAST IRON

By W. S. Owen, Ph.D., M.Eng., A.I.M., and B. G. Street, B.Eng.

Synopsis

The crystal structures of (*a*) graphite extracted from an iron-carbon-silicon alloy prepared from high-purity materials, and (*b*) graphites from a variety of commercial cast irons, have been studied by the X-ray powder method. In all cases the structure was a mixture of the α and β structures found in other graphites of different origin. The proportions of α and β structures present varied considerably in the different forms of graphite, and a correlation between the microscopic appearance and the crystal structure has been established.

The parameters of the unit cells have been measured, and as no variation from the accepted value for pure graphite has been found, it is concluded that the graphite occurring in iron-carbon-silicon alloys and in commercial cast irons is appreciably pure carbon.

THE CARBIDE PHASE IN IRON-CARBON-SILICON ALLOYS

By W. S. OWEN, Ph.D., M.Eng., A.I.M.

Synopsis

The dimensions of the unit cell of the crystal structure of the carbide phase extracted from a plain carbon steel, a commercial white iron, a high-purity vacuum-melted iron-carbon-silicon alloy, and a similar alloy melted in air, have been measured to a high degree of accuracy by a Debye-Scherrer powder X-ray method. No variation in the dimensions of the cell has been found. It is concluded that silicon in iron-carbon-silicon alloys does not enter the carbide phase, and from this it is deduced that the position commonly accepted for the peritecto-eutectic point in the metastable diagram of this ternary system is probably considerably in error.

Discussion

Dr. E. V. Riley (Staveley Iron and Chemical Company, Ltd.) : In the first paper, by Owen and Street, it is concluded that "The crystal structure of any particular microscopic form of graphite is independent of the composition and method of manufacture of the iron." This conclusion appears rather hasty in view of the limited number of specimens of cast iron which have been examined. The specimens of cast iron mentioned include none which contain alloying elements such as nickel, chromium, molybdenum or even silicon above, presumably, 3-4 per cent. The statement that "A wide variety of cast irons, containing graphite in many different metallographic forms, has been investigated," is therefore also misleading. One conclusion of this paper infers that the pure graphite, the material extracted from the cast iron, does not contain any element other than carbon. After the very extensive purification treatment accorded to the extracted graphite, this is to be expected. Presumably this conclusion relates only to the pure material and not to the graphite as it exists in the iron. I feel that in working only with the purified graphite extracted from the iron the authors have tended to side-track one most important issue, namely, the elemental impurities or compounds which may be present in the graphite as it exists in the cast iron. They have established that the purified graphite is the same as graphite from other sources. Can we now expect an extension of this work to obtain information about the nature of the foreign bodies present in graphite as it exists in cast iron? This information may be of vital importance in leading to an explanation of why graphite sometimes occurs in flake form, sometimes in nodular form and sometimes in other forms.

Turning to the second paper, by Owen, it should be recognised that the statement that the solubility of silicon in the carbide phase is negligible must be applied only to irons in the very limited range covered by this research. The author in private correspondence has agreed to this qualification. It is probable that the position will be made clear upon the publication of the results of Dr. Owen's present researches, which have been submitted to the Institute, and possibly in his further researches in the U.S.A.

Dr. A. Taylor (Mond Nickel Company, Ltd.) : I read the paper by Owen and Street with great interest, in the hope that I should learn something about the mechanism of the formation of the spheroids in cast iron, but I was a little disappointed to find that, with all the X-ray work they did, they did not give any hint about how the spheroids or the flakes in cast iron were formed. The authors say : "With the exception of observations made on a kish graphite from a copper steel, reported to give pronounced extra lines of the β-structure, the authors do not know of any recent investigation of the crystal structure of graphite occurring in iron alloys." Actually there is a great deal in the literature about the crystal structure of graphite in iron alloys.

[Here Dr. Taylor made extensive reference to the literature going as far back as 1922.]

The conclusion reached in the paper is that the graphite present in iron alloys does not contain any element other than carbon in appreciable quantities and this seems to be based on the lattice parameter measurements mentioned in the paper. This, of course, can refer only to elements which are actually in solution in between the planes and does not in any way rule out the presence of foreign material in the way of a nucleus at the centre of each spheroid, which some workers believe to exist. It may be that stringent cleaning of the graphite will remove that nucleus, but I think that the penetration will not be good enough to remove that small amount of nuclear material and in any case X-ray methods would not be very sensitive for the detection of small amounts of nucleating constituents. It would be interesting to know whether chemical or spectrographic analyses were carried out to substantiate the statement that the impurities were negligible because it would not be difficult to isolate a fair quantity of clean spheroids and then examine them spectrographically to see whether there was any nucleating constituent in them.

The second paper seems to me to be based on the fact that the lattice parameter of Fe_3C remains constant in the presence of silicon. I should like to mention a paper by Groeber, published in 1937, in which he, too, has measured the lattice parameters of the cementite and finds that they do not change however much the carbon content of the cast iron may be changed and in the presence of silicon. It seems to me that the conclusions reached in Owen's paper bear out the earlier work.

Mr. H. Morrogh (British Cast Iron Research Association) : Dealing first with the paper by Owen and Street, I should like to underline the comments made by the previous contributors to the discussion with regard to the fourth conclusion, which is that "The graphite present in iron alloys does not contain any element, other than carbon, in appreciable quantities." I think that the investigators might have been a little more justified if they had worded that conclusion to read "The graphite present in the extract from iron alloys does not contain any element other than carbon," but even then the statement would be open to considerable doubt. I have carried out a number of experiments in chemically analysing the extracts of graphite from cast irons of a wide range of composition, and we do find that certain impurities are present, such as silica. It could be argued, of course, that the method of extraction is not complete. Earlier in the discussion reference was made to the possibility of impurities being in solution or entrapped interstitially in the graphite spherulites. That may be true ; however, I think it worth while to point out that, whilst these graphite spherulites are produced commercially by the deliberate addition of certain small amounts of elements such as magnesium, cerium and sulphur, it is possible also to produce them deliberately by trying to produce alloys of very high purity. Iron-carbon-silicon alloys prepared in the purest form in vacuum and then subjected to fairly rapid cooling give spherulitic graphite, so that the presence of impurities is not a necessary condition for the formation of those graphite spherulites.

Reference was made earlier to a paper by de Sy, which has attracted some attention, in which he claims to show by electron micrographs nuclei in the centre of graphite spherulites. The spots which de Sy sees in the centre of graphite spherulites can be explained by a simple geometrical consideration of a spherulite. Consider a spherulite consisting of a number of radially dispersed crystallites with their basal planes at right angles to the radii of those spherulites. In a given microsection we shall cut across a number of spherulites, and the crystallite at the centre of that cut will have its basal plane in the surface of the micro-specimen, and graphite viewed normally to the basal plane appears optically quite different from graphite examined at some angle to that basal plane. It exhibits a bright metallic reflection and could easily create the appearance of a nucleus.

With regard to the paper by Owen on the carbide phase in iron-carbon-silicon alloys, I believe that his observations are probably quite correct, but I think that the conclusions which he has drawn are incorrect and are based upon an inadequate appreciation of the metallurgical facts. If we take the eutectiferous iron-carbon-silicon alloys, with increasing silicon content up to about 2·5 per cent the eutectic carbide phase appears to behave as cementite. With silicon contents in excess of 2·5 per cent there begins to appear another phase which metallographically can be distinguished from cementite and appears to be a carbide phase. With increasing silicon it increases in amount progressively, until with about 7 per cent of silicon the original cementite is replaced by this other carbide phase. The highest silicon content examined by Owen was 3·14 per cent. The alloy of that composition would contain only a very small proportion of this second silico-carbide phase, and I submit to the author that his methods were not sufficiently sensitive to detect the presence of that phase.

Mr. B. G. Street replied shortly.

(To be continued)

Gas Turbine Technology.—The courses arranged for 1952 at the School of Gas Turbine Technology, Farnborough Place, Farnborough, Hants, are as follows :—Design and Applications of Industrial Gas Turbines, December 31st to January 18th ; Aero-Engine Design, January 28th to February 15th ; Practical Aero-Engine Course, February 25th to March 7th ; International Course on Aero and Industrial Gas Turbines, March 17th to April 4th ; Design and Applications of Industrial Gas Turbines, April 15th to May 2nd ; Aero-Engine Design, May 12th to May 30th. The design courses are of approximately post-graduate standard and are open to students of British or Commonwealth nationality. They include the running and testing of engines together with performance calculations.

Aircraft Navigational Aids

ONE of the early flight problems to arise with jet traffic control was the liaison between ground and aircraft for navigational purposes and, in particular, positioning.

Previously direction finding was done by a ground operator using aural-null methods, but the time lag required for tuning, checking for true or reciprocal bearings, reading off and transmitting the information to the aircraft made this method useless when an aircraft approached an aerodrome at speeds in excess of 300 m.p.h. In fact, if a request for a bearing was made when the aircraft was 30 miles distant from the aerodrome it might well be used to giving the briefest of calls and getting instantaneous bearings that they are apt to be monosyllabic at times and do not call sufficiently.

From the ground staff's point of view, the visual indication of bearings has given operators increased confidence, and it enables other personnel to check the accuracy of the operator.

During the recent Commonwealth Conference on the operation of jet turbine aircraft a further attachment was demonstrated to delegates; it enables the position of aircraft to be located automatically and instantaneously.

The installation, with this attachment, is

MARCONI V.H.F., D/F INSTALLATION—HATFIELD

past by the time the ground operator obtained a first-class bearing.

Over three years ago this problem was considered by Marconi's Wireless Telegraph Company, Ltd., who subsequently designed and built the Marconi AD.200 V.H.F. D/F installation, which allowed ground operators to read off bearings instantaneously to the pilot of a high-speed aircraft.

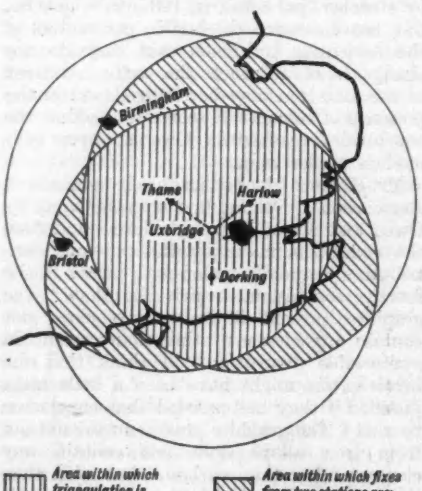
The equipment was compact enough to be unobtrusive in control towers, the main transmitters-receivers being sited at a distance and remotely controlled from the tower. Instantaneous reading of bearings are presented visually on large meters which can be used in conjunction with other repeater meters situated elsewhere.

Nearly two years ago the de Havilland Aircraft Company, Ltd., co-operated with the manufacturers in a particularly searching test, with an AD.200 installed in the control tower at Hatfield mainly for test flying facilities. Our first illustration shows the Marconi installation in the control tower at the de Havilland airfield, Hatfield. On the right can be seen the master control console and the twin receivers, and in the centre of the aircraft control officer's desk is a remote bearing indicator and twin loudspeaker. Numerous incidents in the short career of this equipment at Hatfield are recorded. During the recent Royal Aero Club meeting, which had to be cancelled owing to bad weather, Group Captain John Cunningham made an air inspection of the course in very bad conditions, and although in cloud at 400ft, by flying on the V.H.F. D/F, he went around safely, finding the end of the runway with complete confidence.

The rapidity with which the control tower personnel read-off has occasionally created suspicion in the minds of pilots new to the technique. At other times, it is stated that pilots, when used to the technique, become so able to provide bearing information over long distances, by means of telephone lines or by radio link. Two or more stations can thus be sited at widely separated places, giving suitable baselines in any direction, and their combined intelligence can be gathered at a central point by means of remote repeater indicators.

The bearings obtained are projected on to a translucent map by an ingenious adaptation of the episcope principle; 5in bearing indicators are used in conjunction with wide-angle short focus *f*1·9 anastigmatic lenses. These lenses are of 4in focal length, screw focussed, and mercury vapour lamp illumination is employed.

At the demonstration two twin-channel AD.200 equipments were used. One was sited at Bedells End, Essex, and the other at the de Havilland airfield, Hatfield, Hertfordshire. The latter installation was 35 miles from Baddow and worked, through normal telephone exchanges, with the aid of only one repeater unit. The total line length was 54 miles.



BEARING RANGES

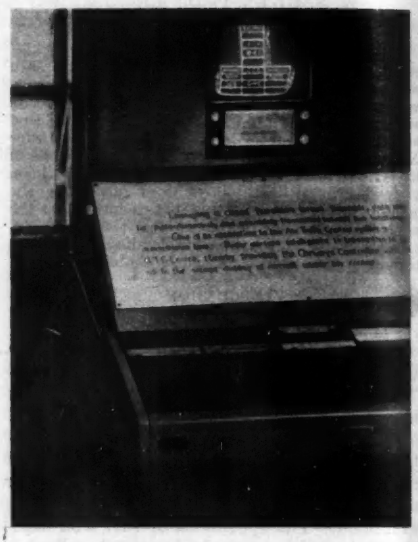
Two narrow beams of light on the translucent map indicated the two bearings taken on the aircraft and presented continuous instantaneous fixes.

One advantage of the system is the fact that a calling aircraft operates a relay system in the receiving apparatus which automatically illuminates the map and draws attention to the fact that fixing is taking place.

An example of the approximate coverage of such a service, using three V.H.F. D/F's, is shown in the diagram reproduced herewith.

Another device demonstrated to delegates during the conference was the Mullard Electronic "Telescribe," in experimental use at the Ministry of Civil Aviation, Air Traffic Control Experimental Unit, London Airport.

The cathode-ray tube shown in our illustration holds information on the positions of aircraft in a "stack." This appears instantaneously on the screen of the receiving unit,



"TELESCRIBE" EQUIPMENT

which, for the purpose of the demonstration, was in the same room as the transmitting equipment.

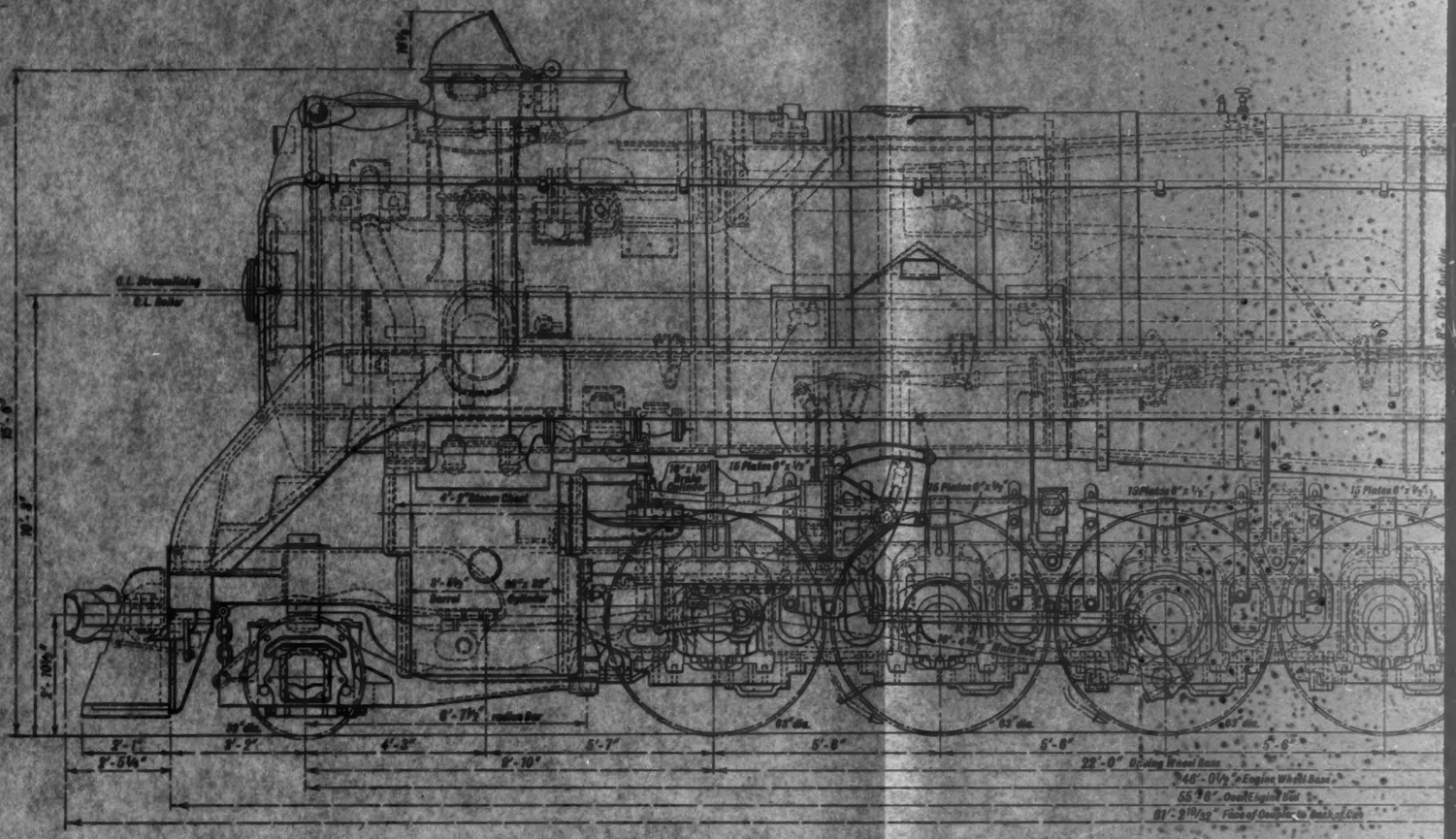
The purpose of the demonstration was to show how information can be exchanged between an aerodrome air traffic control unit positioned, say, at Northolt, and an air route traffic control centre at, say, Uxbridge —some 4 miles away. The importance of the "Telescribe" in such transmissions is governed by the fact that verbal/telephone liaisons are too slow. Moreover, during the period of high air traffic, they are already up to saturation level.

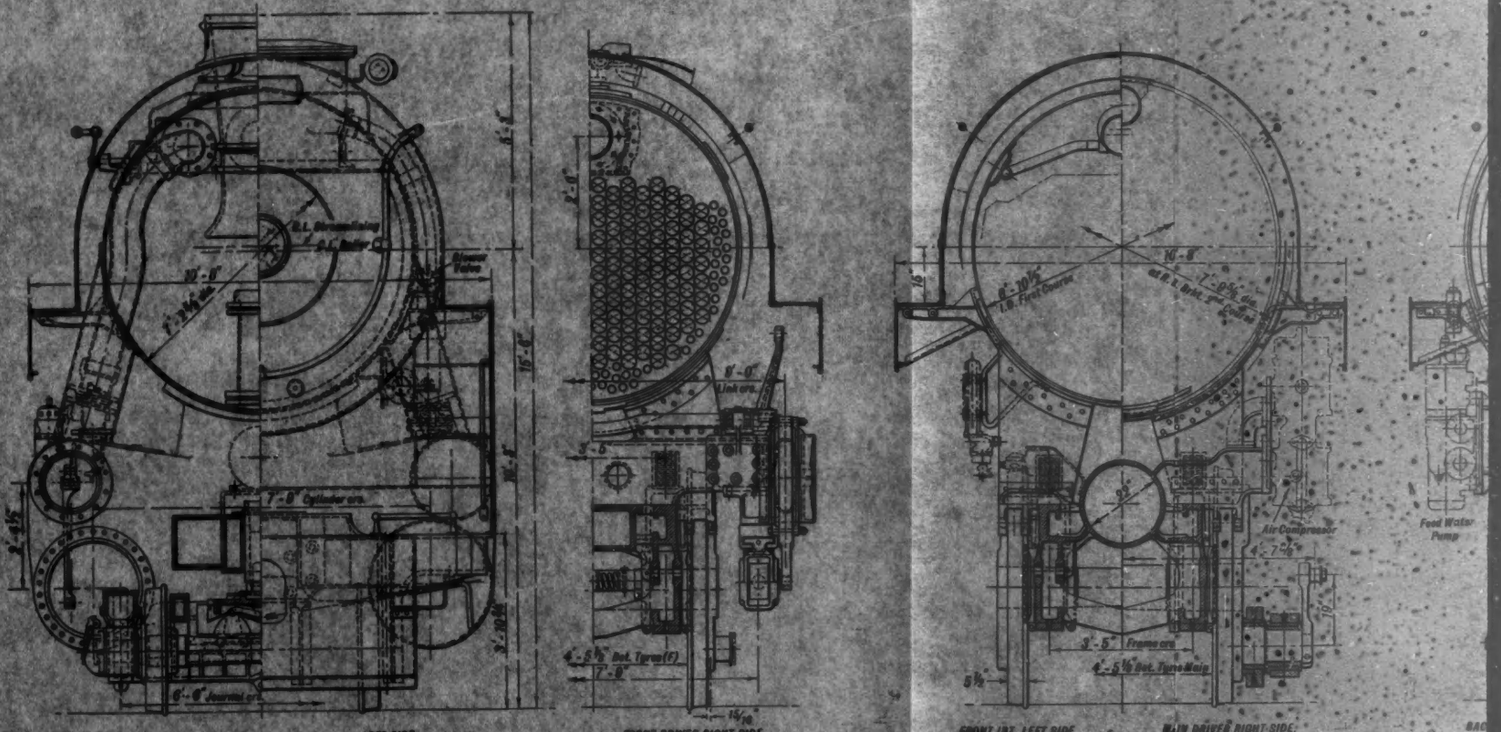
The "Telescribe" was originally devised by Mullard engineers to demonstrate practical possibilities of certain electronic principles, and was first demonstrated at the recent National Radio Exhibition. It enables written messages, tabulated information, maps, drawings, printed matter, photographs, &c., laid down or written on a glass plate, to be transmitted to a distant receiving unit where the data is instantaneously reproduced on the screen of a cathode-ray tube. In addition, it will allow the superimposition of written messages, symbols, drawings or maps on any television or radar display.

The Ministry of Civil Aviation intends to explore the potential applications of the instrument to information transmission problems and, in addition, to P.P.I. radar displays.

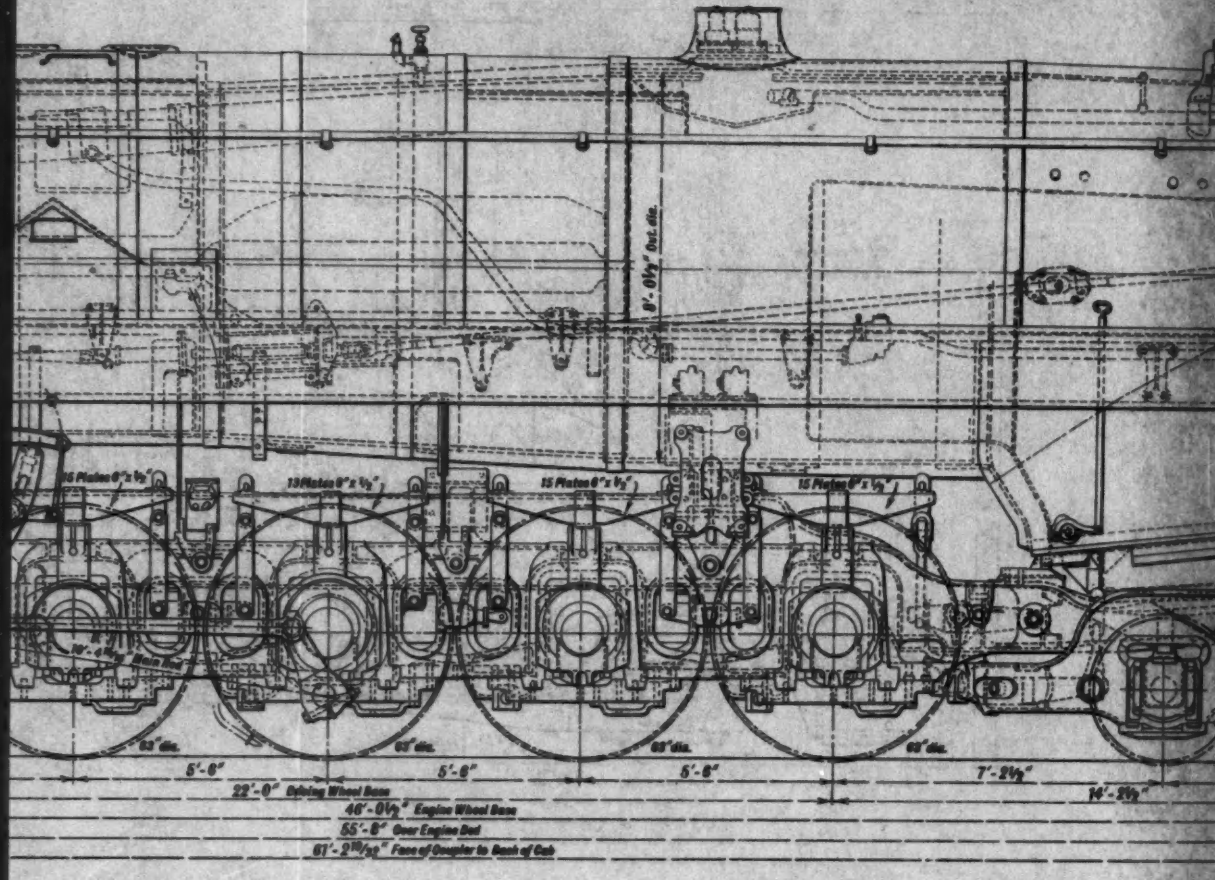
The Ministry of Civil Aviation, has also invited representatives of European civil aviation authorities, airlines and associated aviation bodies to witness a series of flight

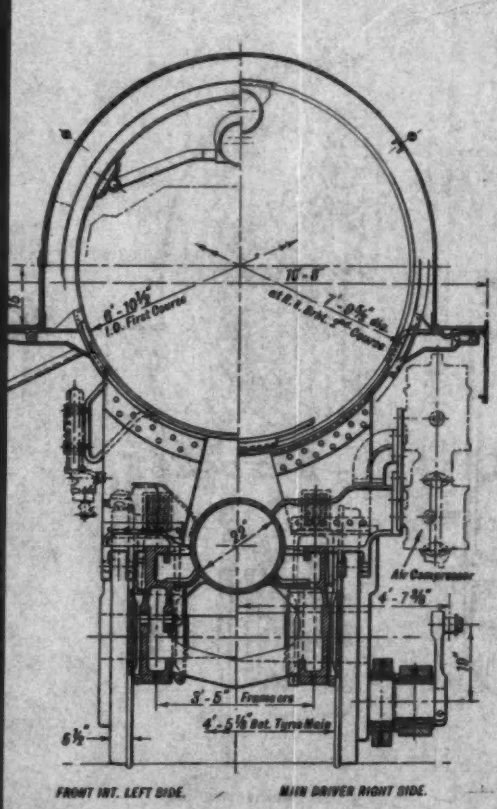
CANADIAN PACIFIC RAILWAY





NADIAN PACIFIC RAILWAY'S "T1c" CLASS LOCOM





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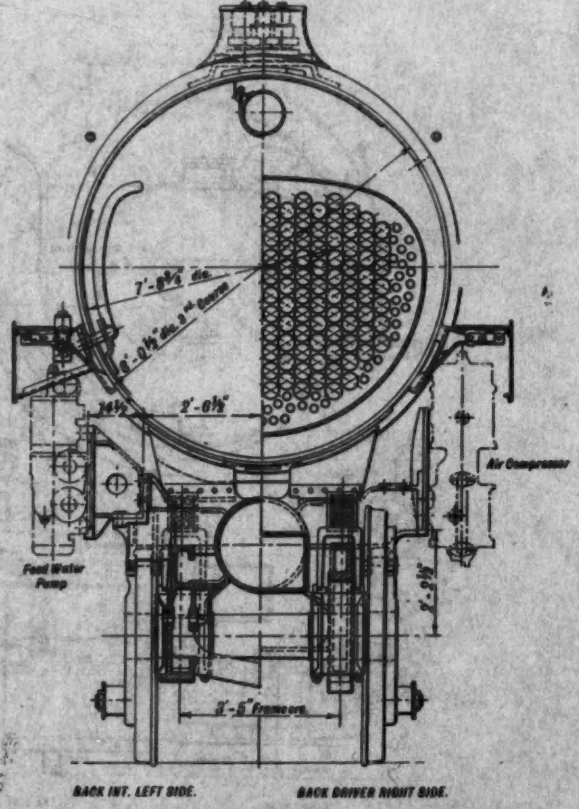

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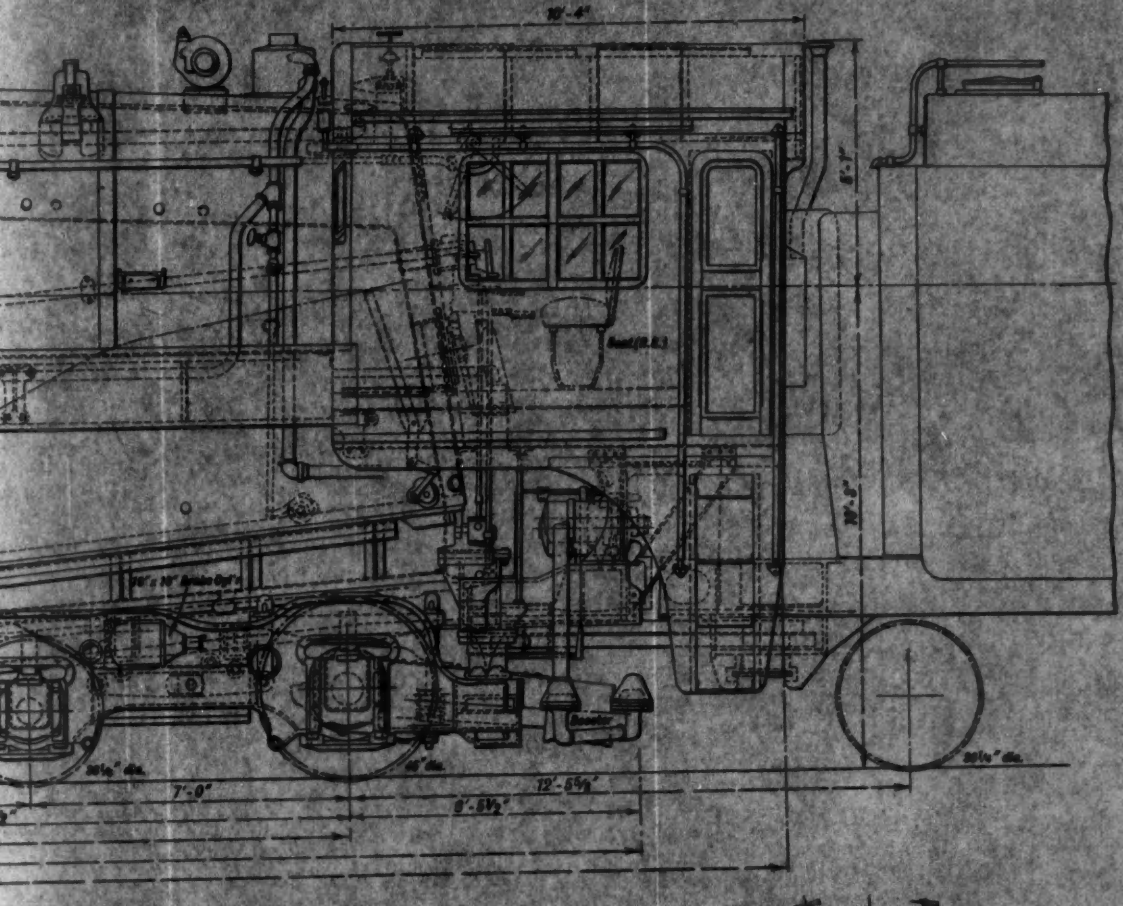
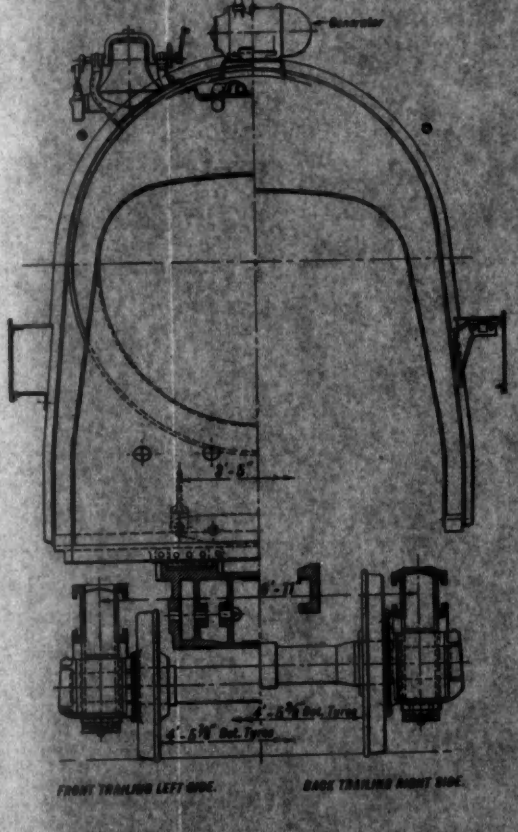
COMOTIVE





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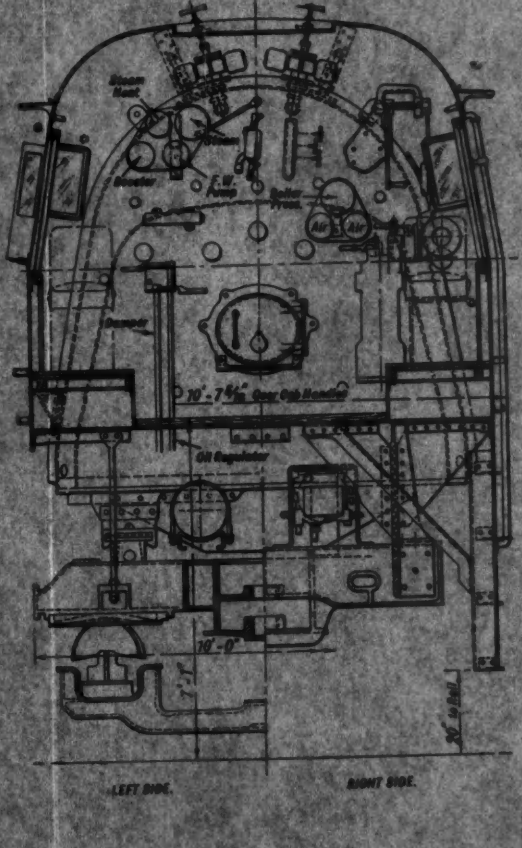

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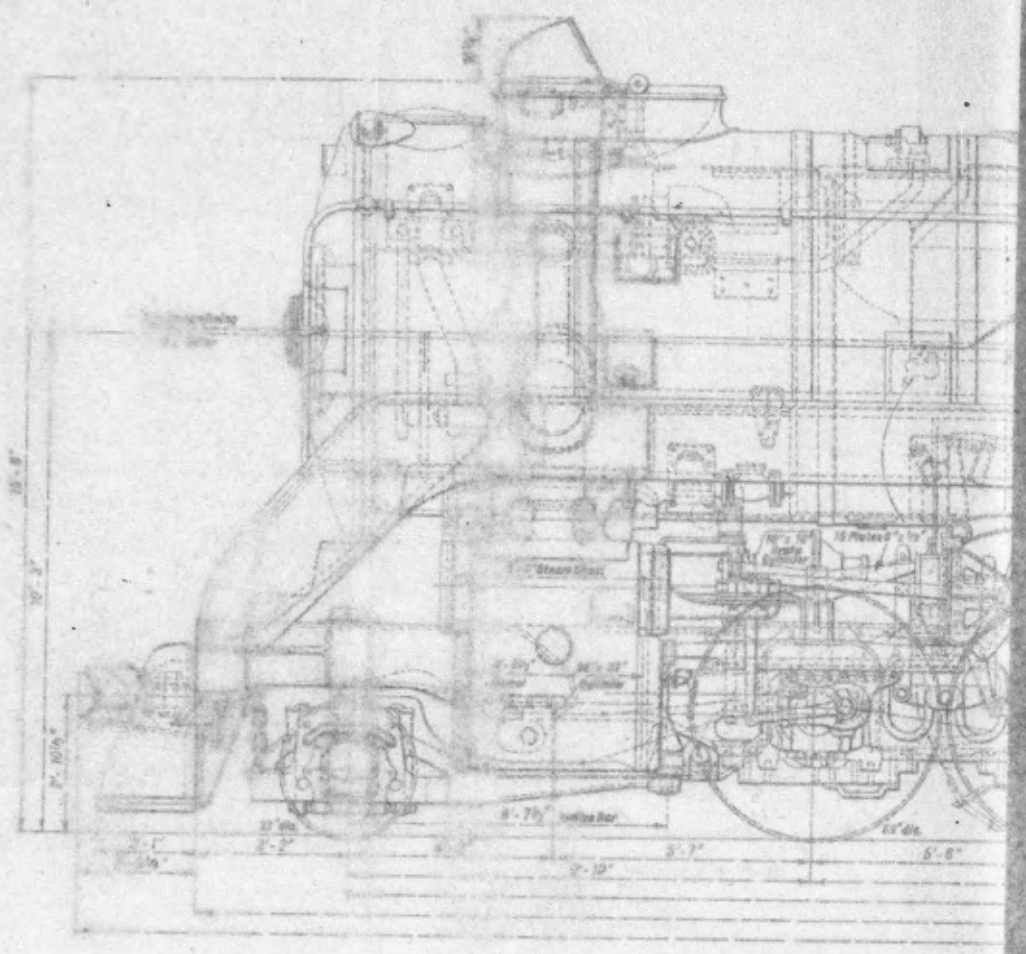
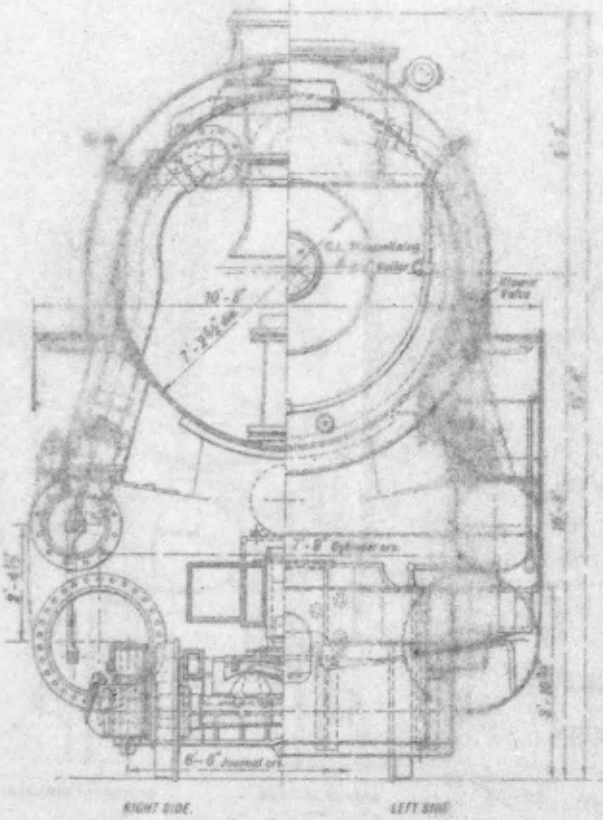
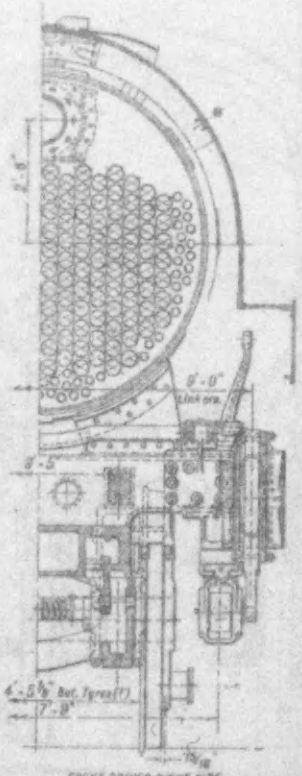






RIGHT SIDE. LEFT SIDE. FRONT DRIVER RIGHT SIDE.

trials of the Decca Flight Log. The testing of the Decca Flight Log under service conditions was recommended by the International Civil Aviation Organisation last June. For the present series of trials a four-engined Handley Page "Marathon" aircraft has been equipped with the flight log.

The equipment is a development of the Decca Air and Marine Navigator system, as described in THE ENGINEER, January 28, 1949, page 101. The Decca Navigator enables a pilot to fix his position at any moment on a chart overprinted with a special lattice. This is done by taking the readings of two Decometers, which continuously receive radio wave signals transmitted by three Decca stations sited on the ground some 60 miles apart, and then finding the point on the chart at which the two accurately indicated position lines intersect.

The Decca Flight Log provides at any moment a pictorial presentation of the aircraft's exact position in relation to the surrounding country and the track the pilot wishes to fly, and records the track already flown. This is done by mechanically amplifying the torque of the Decometer movements, thus achieving a fully automatic plotter requiring no human intervention. Charts of differing scales can be made up into rolls of fifteen and stored in the display head. Should the aircraft cross the boundary of one chart on to another of a different scale, the pushing of a button brings the new scale into effect. The total weight of the equipment is about 120 lb, and its volume is 3·2 cubic feet.

The combined coverage extends over most of the British Isles, the English Channel and North Sea, and over Denmark, the southern part of Sweden, southern Baltic, Holland, Belgium and north-west France. Three more chains are under construction in England, France and Germany, and it is planned to establish a further series of chains which would extend the coverage to the greater part of Western Europe. The results of tests so far carried out suggest that the Decca system and flight log may be able to provide European airliners, particularly medium-speed machines, with a better navigational aid than any at present in use or contemplated, and at a much lower cost than for any comparable system.

The Units of Length, Mass and Time

THE Department of Scientific and Industrial Research has issued the first of a short series of pamphlets dealing with the units and standards of measurement employed at the National Physical Laboratory.* The first of the series is concerned with the primary units of length, mass and time and with the secondary units of volume, density, specific gravity, the acceleration due to gravity, force and pressure.

In general the units used at the N.P.L. are based on both the British Imperial and International Metric Systems. Thus measurements of length are expressed in terms of either the Imperial Standard Yard or the International Prototype Metre and measurements of mass in terms of either the Imperial Standard Pound or the International Prototype Kilogramme.

It is well known that the Imperial Standard Yard is defined as the distance between two lines near the ends of a square sectioned bronze bar in the custody of the Board of Trade when the bar is at a temperature of 62 deg. Fah. Copies of this standard are preserved elsewhere for use in the event of the original being lost or destroyed. The International Prototype Metre is similarly the distance between two lines on a platinum-iridium bar of X-section preserved at the International Bureau of Weights and Measures, Sèvres, near Paris, when the bar is at 0 deg. Cent. Copies of this standard are preserved elsewhere, one being in the custody of the N.P.L.†

By the Weights and Measures Act of 1878 the various copies of the Imperial Standard Yard have to be compared periodically with the Board of Trade's prototype. This statutory comparison is now carried out by the N.P.L. The last one was made in 1947–48, but the pamphlet does not tell us the result.

The British copy of the metre has been in this country since 1889. Since then it has been directly compared only once—in 1922—with the French International Prototype. In 1949 however, it was compared at Sèvres with two copies of the prototype. These comparisons showed that the British copy of the metre agreed with the International Prototype to within one part in ten million.

For everyday use the N.P.L. employs a large number of standards of length of different types and sizes, all derived from the fundamental yard or metre. These working standards are made of nickel, invar, nickel steel or fused silica.

In 1927 international approval was given to a standard of length alternative to the metre, namely, the wavelength in normal air of the cadmium red radiation. This wavelength is accepted to be 6438·4696 Angstrom units (one A.U. = 10^{-10}m). It is suggested in the pamphlet that cadmium as a source of the standard wavelength may soon be replaced by some pure isotope, such as mercury-198, which produces monochromatic light of the highest quality.

The ratio of the British yard to the metre was ascertained in 1895 and was given legal sanction in 1898 at 1m = 39·370113in. Since then the ratio has been determined at the N.P.L. on three occasions. The successive values are as follows :—

1895	1m = 39·370113in
1922	1m = 39·370147in
1932	1m = 39·370156in
1947	1m = 39·370186in

The evidence derived from the determination of the metre in terms of the cadmium red radiation shows that between 1893 and 1940 the metre remained constant to within three parts in ten million. The above figures indicate that the Imperial Standard Yard has decreased by about two parts in a million since 1895. The change was scarcely significant between 1922 and 1932, but between 1932 and 1947 it amounted to about one part in a million, the same as it did between 1895 and 1922. The pamphlet refers to the change in the ratio of the yard to the metre as "embarrassing." For the time being the N.P.L. accepts the 1922 value of the ratio.

Passing from units of length to units of mass, the pamphlet deals with the kilogramme and the pound. The International Prototype Kilogramme is the mass of a platinum-iridium cylinder preserved at Sèvres. A copy of it, received in this country in 1889, is now in the custody of the N.P.L. The Imperial Standard Pound is the mass of a platinum cylinder preserved by the Board of Trade. This is the avoirdupois pound. The troy pound is no longer a legal unit. Copies of the B.O.T. Standard Pound are deposited with several bodies. They are compared with the prototype by the N.P.L., the last comparison having been made in 1947.

The working standards of mass used at the N.P.L. are of many denominations of kilogrammes and pounds, ranging from 20kg and 50 lb down to small fractions. These weights are derived by appropriate comparisons from the fundamental standards. In general the working standards are made of materials, such as nickel-chromium alloy, stainless steel and aluminium, which are of much lower density than platinum. In deriving and comparing them, therefore, special attention has to be paid to the buoyancy correction. For this purpose the density of the ambient air is calculated on a basis which takes account of its temperature, pressure, humidity and CO_2 percentage.

The ratio of the pound to the kilogramme was found in 1883 to be as given below. Two later re-determinations were made by the N.P.L. in 1922 and 1933.

1883	1 lb = 0·45359243kg
1922	1 lb = 0·453592343kg
1933	1 lb = 0·453592338kg

The two later values closely agree, but they differ from the first by about one part in five million. The pamphlet says that "While this difference is not so embarrassing as the corresponding changes in the ratio of the yard to the metre, it is an unsatisfactory feature which should be eliminated." Steps to that end are now being considered.

The unit of time employed at the N.P.L. is the mean solar second and is in effect the one 86400th part of the interval between two successive time signals emitted at 10 hours G.M.T. from the Royal Greenwich Observatory through Rugby radio station. When high accuracy is required, as in the determination of the performance of precision clocks and in frequency standardisation, corrections are applied to cover "times of reception," fluctuations in the period of rotation of the earth and the wandering of the earth's poles.

In practice time measurements at the N.P.L. are made by reference to various precision clocks, of the quartz oscillator, Shortt free-pendulum or other type. The errors of these clocks are determined daily from the Rugby time signals. The quartz oscillator clocks with the time signals as control are accepted as giving the standard of time and frequency at the N.P.L. The Shortt free-pendulum clock is accepted as giving a convenient standard when a precision not finer than 0·005 second is sufficient.

The first of the secondary units to be considered is that of volume. In both the metric and the British systems there are two units of volume. The first is the cube of the unit of length—the cubic metre or the cubic yard—and the second is the volume occupied by a specified mass or weight of water—the litre or the gallon.

It was originally intended that the kilogramme should be the mass of a cubic decimetre of pure water under specified conditions. Had this condition been fulfilled the litre would have been exactly 1 cubic decimetre. The intention proved very difficult to carry out. The kilogramme is now defined independently as the mass of the prototype platinum-iridium cylinder preserved at Sèvres. As a result the litre is slightly greater than a cubic decimetre. It has been established that 1 litre = 1·000028 cubic decimetres with a probable accuracy of ±0·000001.

In the Weights and Measures Act of 1878 the gallon was defined as the volume occupied by a quantity of distilled water which weighed 10 Imperial Standard Pounds, the weighing being carried out in air against brass weights, the air and water being at a temperature of 62 deg. Fah. and the barometer being at 30in. No precise experimental determination has been made into the relationship between the two units of volume on the British system corresponding with the metric system relationship given above. However, using the metric relationship and the known ratio of the pound to the kilogramme and of the yard to the metre, it can be deduced that 1 gallon = 277·420 ±0·001 cubic inches.

It is of interest to learn that, although both the litre and the gallon are based on definitions involving the mass or weight of a quantity of "pure" or "distilled" water, the absence of any reference to the isotopic content of the water has not led to any practical difficulty in interpreting the definitions.

Densities and specific gravities of solids are determined at the N.P.L. by hydrostatic weighings on the basis of standard values for the densities of distilled water and of air. In the case of liquids they are determined either by hydrostatic weighings or by means of standard hydrometers calibrated by hydrostatic weighings.

The acceleration due to gravity at the latitude, longitude and elevation of the N.P.L. has

* Obtainable from H.M. Stationery Office, price 9d. (10½d. by post).

† In view of these definitions, the yard and the metre are clearly arbitrary units. We note with a little surprise that the pamphlet describes them as "absolute measures of spatial distance."

been found by direct experiment in the Metrology Department to be 981·1832cm per second per second.

For work involving the measurement of force or pressure the Laboratory has previously used as standards the weights of certain masses under the local value of gravity. It has, however, recently been decided to change this practice and to express results in terms of the standard value of gravity, namely, 980·665cm per sec² (32·1741ft per sec²). This change will be in conformity with the standard value of gravity adopted in the International Steam Tables of 1935 to convert gravitational units of force and pressure into absolute units.

Pressures in the atmospheric range—from 0 to 900mm of mercury—are expressed either in dynes per square centimetre or in terms of the hydrostatically equivalent column of mercury. For meteorological work the usual unit is the millibar, which is equal to 1000 dynes per square centimetre. For precise scientific work the Laboratory uses the almost universally employed unit of 1mm of mercury at 0 deg. Cent. and g=980·665cm per sec.². In aeronautical work the units used may be either 1in of mercury at 62 deg. Fah. at mean sea level in the latitude of London or 1mm of mercury at 0 deg. Cent. at mean sea level in latitude 45 deg. (g=980·62). No explanation is given as to why aeronautical pressures should be expressed in these special units.

A Helicopter Ambulance

Preliminary details of the "Sycamore 10," ambulance version of the Bristol "171" single-rotor helicopter, have recently been released by the Bristol Aeroplane Company, Ltd. This version has been designed for air ambulance work and general communications operations and is now undergoing an intensive Ministry of Supply test schedule at Boscombe Down.

It has been demonstrated to Service officers and more recently undertook casualty evacuation in the Army exercise "Surprise Packet." Extensive modifications have been carried out to enable the aircraft to accommodate two stretchers, which are carried one above the other athwart the machine. To house the stretchers, two large "Perspex" blisters have been incorporated, one on each side of the fuselage. They are detachable and can be replaced by ordinary faired units when the aircraft flies in a normal communications role.

Hinged doors, which may be jettisoned if necessary, replace the normal sliding doors, as these would be rendered inoperative by blisters.

A metal structure to support the lower stretcher can be folded back as necessary to provide three normal passenger seats. The upper stretcher is supported by bars normally housed in a vertical position alongside the engine bulkhead; when needed they can be swiftly swung into position and made firm with a quick-release pin. Both stretchers are secured by clamp mechanisms.

The engine bulkhead also carries a housing for bottles of plasma and a plug socket for electrically heated blankets for use in cases of exposure or shock.

In the air ambulance role the aircraft carries a medical attendant who sits in a swivel chair beside the pilot, and for normal communications work the attendant's chair and the rear accommodation provide seats for four passengers.

The prototype of the Bristol "171" first flew on July 24, 1947, and was the first helicopter to be built by the Bristol Aeroplane Company, Ltd.

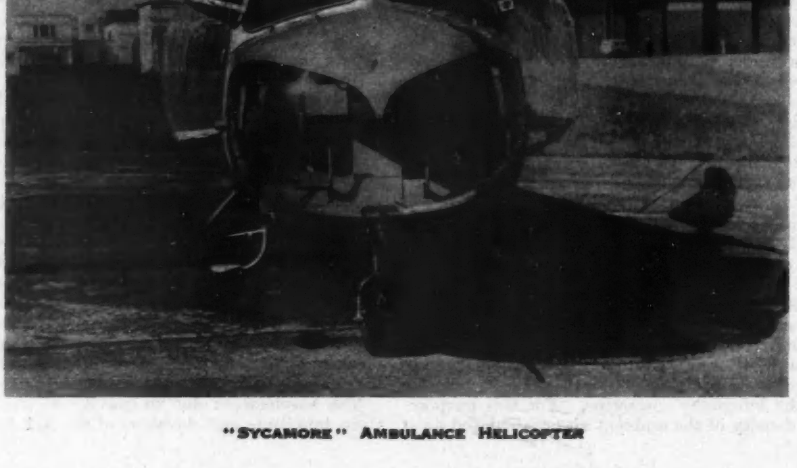
Its design has been influenced by considerations of safety and long life. Among many safety features is the use of a main rotor with a comparatively high moment of inertia and capable of running at high r.p.m. By this means sufficient kinetic energy is produced to ensure a safe and comfortable landing in emergency. Use of a high rotor speed also reduces certain vibration characteristics common to most helicopters, enabling the machine to fly at more than 100 m.p.h. with greater passenger comfort.

All moving parts of the Bristol "171" have an estimated minimum life of 7500 flying hours. It is stated that the main structure of the fuselage is designed to withstand the worst out-of-balance forces which might be imposed by a damaged rotor.

Fuel is carried in a crashproof "bag" type tank aft of the engine and well away from the cockpit.

The Mark 3, now in production, has an Alvis "Leonides" L.E.23 HMV engine of 550 h.p., and nose and cabin lay-out have been considerably improved. The engine is mounted with the crankshaft vertical.

It will be remembered that in September, 1948, this helicopter took part in the demonstration known as "Operation Hare and Tortoise," planned to demonstrate the potentialities of the helicopter. It was flown to a bombed site car-park near St. Paul's, where it picked up a letter from the Lord Mayor of London to the President of the Municipality of Paris. Flying to Biggin Hill, the pilot of the "171" handed the letter to the pilot of a "Meteor," who in turn delivered it to another helicopter pilot at Orly Airport on the outskirts of Paris. Within forty-seven minutes the letter had been delivered from the centre of London to the centre of Paris.



"Sycamore" Ambulance Helicopter

Engine Service Counters

For certain mobile and static power units engine builders are adopting schedules for servicing, oil changing and major overhauls based on the number of hours run or "service hours" principle. With this system is eliminated both the necessity of keeping accurate records of running and dependence upon rougher estimates of overhaul cycles. Counters for indicating the numbers of hours an engine has run have been developed by Smiths Industrial Instruments, Ltd. Two sizes of counters are available, one known as the light duty and the other the heavy duty engine service counter.

The mechanism has in each case an input spindle running at engine speed or some speed exactly proportional to the crankshaft. Worm and wheel reductions convert the rotation so that the unit counter wheel moves through

Light Duty Engine Service Counter

one figure each hour. The counter wheels are linked so that total counts up to 10,000 hours can be indicated.

The light duty engine service counter, as illustrated, is for use on the lower horsepower range of engines, whether these engines are used on static equipment such as generator sets, power packs, &c., or on mobile equipment such as agricultural tractors, factory goods trucks and the like. The frame and casing is made from a zinc-base diecasting chemically treated and enamelled to resist the effects of the weather. The counter has a range of speeds of input between 375 r.p.m. to 1500 r.p.m. When it is used on diesel engines an angle drive is available, enabling the counter to be fitted to the fuel injection pump. The heavy duty engine service counter has been developed for more rugged service where vibration and shock loadings are severe, also where climatic conditions may vary from arctic to tropical.

The construction of the main frame of the counter is based on an aluminium casting anodised to resist the action of sea water, whilst the cover is of pressed steel chemically treated and enamelled. The counter is fitted with rubber gaskets, which give complete water-tightness. An oil seal is fitted to the input spindle to prevent oil flooding into the counter, thereby obscuring the figures. Ratios of 16 r.p.m. to 6000 r.p.m. cover all the speed ranges likely to be encountered, and both counters are calibrated on the average or normal running speed of the engine. Attachment to the engine in the case of both counters is by means of a loose-fitting clamp ring which can be made to suit individual engine conditions.

Ferguson Brothers (Port Glasgow), Ltd., has received an order from the Aden Port Trust to build a seagoing salvage and towing vessel having steam reciprocating machinery.

Conversion of a "Victory Ship"

THE S.S. "Notre Dame Victory" has been converted for the Great Lakes ore-carrying trade and renamed S.S. "Cliffs Victory," and has entered the iron ore transport service for the Cleveland-Cliffs Steamship Company. The ship was converted at the Baltimore Yard of the Bethlehem Steel Company, towed down the coast, up the Mississippi River through Chicago into Lake Michigan, completed there and then sailed to load her first cargo of ore, all within the short time of 167 days.

In the autumn of 1950 it was apparent that the tonnage available on the Great Lakes for the 1951 season would be inadequate for carrying the ore required for the increased steel production planned for this year. Building berths on the Great Lakes were fully occupied and, as additional facilities for new construction were not available, the Cleveland-Cliffs Steamship Company considered the conversion of a vessel outside the Great Lakes area in time to carry ore during the 1951 season. Before making the final decision it was necessary to determine that a ship of this size could be brought into the Great Lakes. A survey was made and it was found that the only possible route into the lakes was up the Mississippi River and through the Illinois Waterway and the Chicago Sanitary and Ship Canal into Lake Michigan. In making the survey the critical points were determined, bridge clearances were measured and fresh soundings were taken. It was found that over the route of 1510 miles are nine locks, 122 bridges and seventy-seven aerial crossings. Lake Michigan is approximately 580ft above sea level.

The maximum length of the ship was governed by the dimensions of Lockport Lock and by construction work in progress at Congress Street in Chicago, and a study of these factors resulted in a recommended maximum length of ship of 626ft. To accommodate a vessel of this length in Lockport Lock, it was necessary to swing the stern and close one mitre gate at a time and this condition limited the maximum beam of the ship to 70ft, a dimension which was also a maximum for passing Congress Street, in Chicago.

The lowest fixed structure was the Marseilles Highway Bridge over the Illinois River. Allowing a clearance of 1ft under the keel and 2·4ft between the ship and the underside of the bridge indicated that the maximum overall height of the ship's structure should be limited to 53ft 6in. The only critical depth of water in the Mississippi below Alton exists over the "Chain of Rocks," just above St. Louis, where the depth has been less than 9ft, and so the light draught was fixed at 8ft 6in, while at other points along the route, depending upon the height of water at the time of transit, a ballasted draught of 20ft 6in may be necessary.

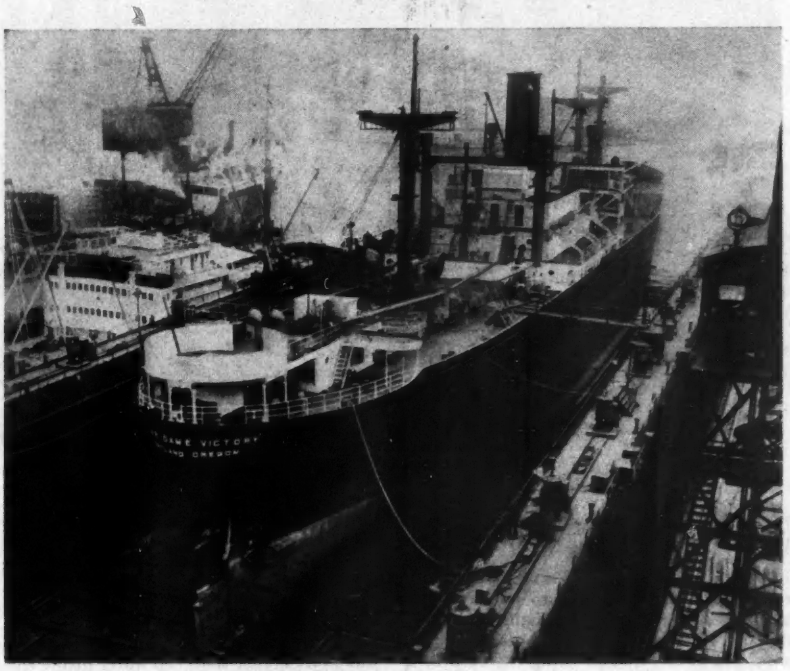
To conform with the limiting dimensions, the "Notre Dame Victory," illustrated herewith, a unit of the U.S. Reserve Fleet, was selected. Built at Portland, Oregon, in 1945, the vessel is powered by a cross-compound, double-reduction geared turbine with a normal rating of 8500 s.h.p. at 85 r.p.m., taking steam from two oil-fired, sectional-header, single-pass water-tube boilers with forced draught. The principal dimensions of the ship before and after conversion are :—

	Before conversion	After conversion
Length overall	455ft 3in	620ft 3in
Length between perpendiculars	436ft 6in	601ft 6in
Beam moulded	62ft 0in	62ft 0in
Depth to main deck	38ft 0in	38ft 0in

The new section, 165ft long, to be inserted in the existing ship just forward of the midship house, was constructed at the Sparrows Point Yard of the Bethlehem Steel Company, launched and then towed to the Baltimore Yard for joining between the two portions of the original ship, from which the original fittings and the necessary structure had been removed. Certain structural alterations were made and sloping, longitudinal bulkheads were installed to form the sides of the forward ore holds. The space outboard of these bulkheads and below the second deck became the wing ballast tanks and the existing double-bottom structure was altered to allow the ballast tanks to extend into the centre-line of ship, while the tank top was strengthened to form the bottom of the ore hold. The space above the second deck on each side became a forward and aft passage under the main deck, which was fitted with heavy transverses and the usual ore hatches, corresponding to Great Lakes practice.

To provide the necessary additional longitudinal strength, plate doublers were fitted at the sheer strake and deck, and to meet depth limitations every part of the vessel above the cabin deck was removed. The new funnel, main mast and the bridge structure were temporarily erected and then stowed on the main deck for the passage to Chicago. Our illustration shows the converted vessel ready for the long tow to Lake Michigan.

When fitting the new middle portion in dock a 9ft gap was left between the new and the old sections and this portion was framed and plated in place to ensure fairness. The joining was by welding. In order to maintain a draught of 8ft 6in it was necessary to provide supplementary buoyancy at the stern of the vessel to reduce the known trim by the stern in light condition. This was done by fitting to the hull blisters, which extended over a length of 120ft aft and which were subdivided into compartments and connected to the ballast



SHIP BEFORE CONVERSION

SHIP READY FOR DEPARTURE

piping system to control the amount of buoyancy required.

A new ballast system was installed in the ship and each pump room, port and starboard of the settling tanks, was equipped with a pump having a capacity of 9000 gallons per minute and a stripping pump of 1800 gallons per minute capacity and a cross-over line.

To provide electric power during the lay-up season in the Great Lakes a 175kW diesel generator was installed and was used to provide power to operate the winches, ballast pumps, auxiliaries and electric lights during the tow to Chicago.

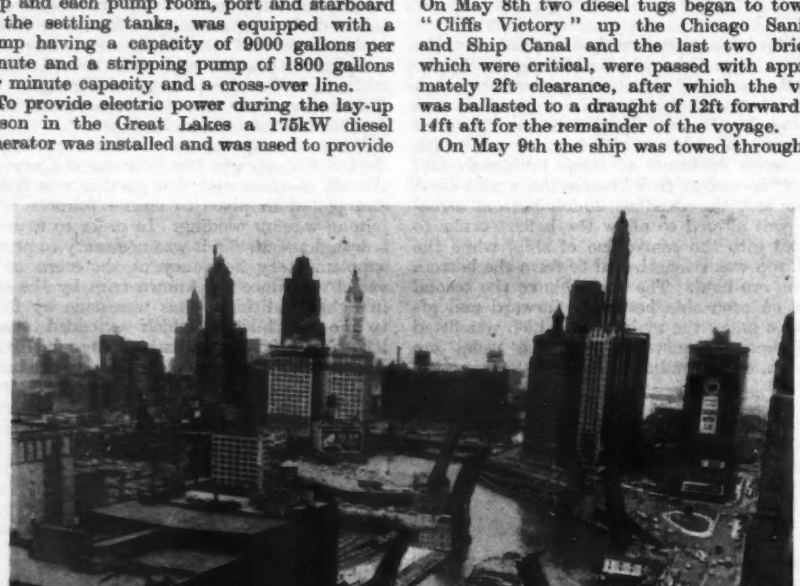
The propeller and rudder were stowed on board to reduce aft trim and to protect them from damage, and a check on the ballast arrangements showed that it would be necessary to a forward hold in order to bring the ship to a 20ft 6in draught. The "Cliffs Victory" sailed from Baltimore on April 2, 1951, in tow of the 1800 h.p. diesel-electric tug, and arrived in New Orleans on April 18. The ship was brought to an even keel draught of 9ft and with three loaded barges in tandem lashed to the starboard side was pushed up river by a steam tug of 2000 h.p. The tow left New Orleans on April 19th and reached St. Louis, Missouri, on May 2nd. The Chain of Rocks, above St. Louis, was passed without difficulty, the minimum sounding being 14ft. At Grafton, Illinois, the tow left the Mississippi and proceeded up the Illinois River.

The first locks on the Illinois, La Grange and Peoria, presented no obstacle as the river was high and both gates were dropped and the tow sailed straight through. Each of the locks on the Illinois River is 600ft long and 110ft wide, and with the exception of Lockport, all have mitre gates. The total width of the ship and the barges was 97ft and at each of the locks below Lockport the ship and two barges locked through together, followed by the tug, with one barge. Constant tension electric mooring winches installed forward and aft assisted in manœuvring the ship out of the locks.

At Lockport, reached on May 6th, it was necessary to lock the ship through alone, so that the ship could swing from side to side to allow the mitre gates at the lower end of the lock to close separately. The highest lift at any one lock had been 40·3ft at Lockport, and the total lift of all the locks on the Illinois Waterway was 128·2ft.

The most critical point along the route below Lockport was the bridge at Marseilles Highway and the tow passed under this bridge with less than 2ft vertical clearance and with approximately 3ft of water under the keel. On May 8th two diesel tugs began to tow the "Cliffs Victory" up the Chicago Sanitary and Ship Canal and the last two bridges, which were critical, were passed with approximately 2ft clearance, after which the vessel was ballasted to a draught of 12ft forward and 14ft aft for the remainder of the voyage.

On May 9th the ship was towed through the heart of Chicago without mishap and passed a total of thirty-three bridges, some of which can be seen in our illustration, before she arrived at the entrance to Lake Michigan. Although there was not sufficient clearance to close the gates at the lower end of the lock and the level of the water of Lake Michigan was 1·4ft higher than the water inside the lock, the outer gates were opened. After the first rush of water the vessel was pulled forward to clear the lower gates, which were then closed to shut off the lake flood water from the river. Finally the "Cliffs Victory" was towed down the lake and, on May 13th, reached the South Chicago Yard of the American Shipbuilding Company, where the ship was completed. After successful trials, when a speed of 20·3 m.p.h. was attained, the ship sailed on her maiden voyage as an ore carrier on June 4th.



SHIP PASSING THROUGH CHICAGO

Symposium on the Jointing of Aluminium

As recorded in a Journal note two weeks ago, the Aluminium Development Association held a "Symposium on Welding and Riveting Larger Aluminium Structures," on November 13th, at which four papers were read, two dealing with welding and two with riveting, and they are summarised below.

The first paper read is entitled "Recent Researches on the Arc Welding of Thick Aluminium Alloy Plate," by P. T. Houldcroft, B.Sc., W. G. Hull and Dr. H. G. Taylor.

This paper discusses the problems involved in joining thick plate, the materials normally welded and some of the techniques which have been employed. Arc welding methods which are particularly suitable for welding thick material are dealt with, namely the metal arc and argon arc processes and two other processes in which an inert gas is used to shield the weld pool. The latter methods are called the self-adjusting arc and the controlled arc processes.

Special considerations in welding thick plate are recorded, such as the necessity for high heat input, the number of passes and the form of edge preparation. The only heat-treatable alloy which is fusion welded to any great extent is the aluminium-magnesium-silicon alloy, while most non-heat-treatable alloys in common use may be satisfactorily welded. Cracking tendencies of various alloys when gas welded under restraint are listed and the cause and prevention of gas porosity is discussed, particularly the need to remove the potential sources of hydrogen if sound welds are to be produced.

The advantages and disadvantages of the metal arc process are considered. The equipment is simple and robust and the welding speeds are high, but the main drawbacks are the necessity for slag removal, flux entrapment and the need to ensure that the electrode coating is free from moisture. Mention is made of the three alloys currently used for core wire and the effect on welds by coating aluminium-magnesium electrodes by dipping in a molten flux bath is tabulated. Metal arc welding techniques are described, recommendations made and the two-electrode method, for avoiding breaks in welding, due to electrode change-over, is noted.

In the argon arc process three welding power conditions, namely, direct current with straight and reversed polarity and alternating current are examined. When using alternating current the need for correct phasing of the input supplies to the high-frequency unit and the welding transformer to avoid rectification is emphasised, and effect of unsuitable phasing conditions is shown by oscillograms. Equipment is briefly reviewed and techniques generally discussed. An outline of the self-adjusting arc process, known in the United States as "Aircomatic" welding, is described and illustrated diagrammatically. Welds can be produced in all positions and a high rate of deposition maintained, which reduces operator fatigue and localises heat. Another process, known as the controlled arc process, which is suitable for mechanised welding, is described and a table gives comparative welding speeds and gas consumptions of the process and those obtained by argon arc welding. In conclusion the authors state that with the argon arc and self-adjusting arc processes available practically no restriction exists on the design of a joint.

In the second paper, "Practical Aspects of the Argon Arc Welding of Aluminium Alloy," read by J. R. Handforth, M.Sc., brief notes are given on the general principles of the argon arc process and the two essential problems involved are examined, namely, the development of the heat required in the material to be welded and the maintenance of an oxide-free surface on the materials. The electrical apparatus, torches and tungsten electrodes are touched upon, while filter rods are discussed at greater length, rod diameters related to sheet thickness are given and comparative strengths for dressed and undressed welds tabulated. Hand welding and machine welding techniques are described and many practical recommendations are made, while data on working conditions and relative costs is given for a number of illustrated examples. The paper includes a selected bibliography from which further information on practical applications of the process may be obtained.

The next paper, "The Properties and Driving of Large Aluminium Alloy Rivets," given by J. C. Bailey, B.Sc., discusses the progress made in recent years in the use of rivets larger than ¾in diameter. A table gives the properties of rivet alloys and the grain flow of the material in the rivet after manufacture is illustrated, together with hardness values after driving. The powers required to form various shapes of point in a range of alloys by hydraulic squeeze riveting are set out in tabular form, which shows that the flat point is the easiest to form, the snap point being the hardest. In riveting by pneumatic hammer or by hand hammer the rivet is closed more effectively by a few heavy blows rather than many light blows, so that a heavier tool than used for driving a hot steel rivet is necessary. The

practical temperature range for hot driving of non-heat-treatable aluminium-magnesium alloy rivets is 400 deg. to 500 deg. Cent., and the methods for driving heat-treatable alloy rivets are reviewed, cold closing immediately after solution treatment being recommended.

To make the closing of large-diameter rivets easier various small rivet point shapes have been evolved, such as the small pan, recessed and annular points, all of which are described and illustrated. Riveting preparation factors are reviewed and a table lists the maximum rivet sizes, in association with point shape, which can be driven by a pneumatic hammer having a 9in stroke by 1 1/16in bore. Shear strengths of cold-driven rivets are listed and the paper states that present driving techniques and point shapes enable ¾in diameter rivets to be driven under practical conditions.

The fourth paper is entitled "The Design Characteristics of Aluminium Riveted Joints," by Professor S. C. Redshaw. Various factors influencing the design of aluminium riveted joints are discussed, the effect of variations in materials and proportions are considered, and the paper shows how research results can be used by the practical designer. The aluminium joint has a frictional resistance of one-tenth that of steel, and as the aluminium rivets are driven cold the clamping effect is reduced. Double riveted joints were used for the tests and actual rivet deformation curves were used in analysing the joints considered.

The relative merits of a joint calls for an examination of the materials used and the proportions adopted, and these factors are considered. Rivet and plate materials are discussed, as are joint proportions, especially with reference to the number of rows of rivets, rivet pitch, rivet diameter to plate thickness ratio, ratio of sectional areas of connected members, and the effect of the reduction in the number of rivets in the end rows. In eccentrically loaded joints deductions from previous work are stated and an explanation given why this joint shows an increase in strength while an axially loaded joint shows a decrease. The question of fatigue resistance is generally examined and tests indicate that failure in double shear joints nearly always occurs in the plates. In conclusion, five recommendations are given for the design of joints and, if observed, they will make the assumption of equal load distribution among the rivets reasonably accurate. The characteristics are: rivet alloy to be as ductile as possible, compatible with static strength; ratio of proof to ultimate stress of plate alloy to be high enough to prevent plasticity before maximum load is reached; length of joint and pitch of rivets as small as possible; and the rivet diameter/plate thickness ratio should allow high ductility in the rivet without loss of strength.

The Applicability of Gas Turbine Technology*

W. E. P. JOHNSON, A.F.C., C.P.A.†

THE application of the gas turbine to industry generally and for process work in particular is still in the early stages. In consequence, much has still to be learned about its capabilities, costs and economy; nevertheless, it is already plain that there exist many applications where the gas turbine can at the present time be employed with profit. There are now on order or being made in this country industrial gas turbine sets with a capacity totalling over 200,000 h.p. The tendency of gas turbine manufacturers is to adopt a cautious policy of applying the gas turbine where there is a completely obvious application without going to too many complications involving control temperature and other problems.

The gas turbine finds a field opening up in the use of waste heat. In many chemical and industrial processes heat is evolved and thrown away into the atmosphere. It is true that such waste heat could be used in a boiler and the steam generated turned into power or used in processes. This, however, involves the capital cost of a boiler working at high pressure and its many auxiliaries and the maintenance thereof, whereas in the gas turbine waste heat cycle no boiler is required or, alternatively, if an air heater is used, such an item works at comparatively low pressure and consequently low tube stresses, which may reduce the cost. It should be noted, however, that experience with air heaters is as yet very limited and the question of costs still indeterminate.

Gas Turbine Systems

In a simple waste heat gas turbine using the inverted cycle, the hot waste gases enter the turbine at atmospheric pressure, expansion

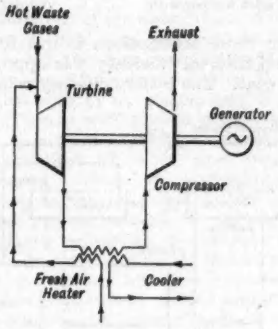


FIG. 1

occurs, and thereafter, the gases are cooled and emerge at slightly above the water temperature; they are then compressed to atmospheric pressure and discharged. The essential simplicity and cheapness of such a cycle is obvious. The thermal efficiencies at the turbine couplings are of the order of 16 per cent with the turbine inlet temperatures in use at present, but the capital costs, maintenance and operating costs will be small. Some gain in efficiency and therefore output can be achieved on this cycle by the addition of a heat exchanger as shown in Fig. 1. In this way the efficiency can be improved to some 18 per cent. At the same time, the turbine inlet temperature is reduced, thus permitting the use of cheaper materials in the construction.

One of the big problems associated with gas turbines at the present time is that of coal burning. With coal, we are presented with the difficulty of disposing of the ash content.

The alternative to direct coal burning is to heat the air supply to the turbine indirectly in an air heater.

The efficiency of a simple gas turbine cycle

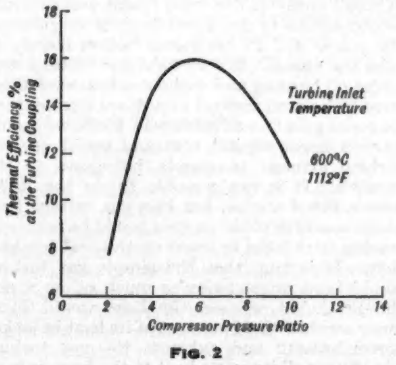


FIG. 2

depends largely on the two factors of pressure ratio in the compressor and turbine inlet temperature.

It will be seen from Fig. 2 that, to develop the full efficiency of such a cycle, fairly large compressor pressure ratios are required and that the peak efficiency is of the order of 16 per cent. This efficiency is not very high, but machines built on this basic cycle can find a niche for themselves as was pointed out earlier. With coal as our fuel, however, we must make modifications to the cycle. Thus, instead of a combustion chamber situated directly in the gas turbine fluid stream, we have an air heater or, as we may call it, an air boiler. Unfortunately, such a system has a lower efficiency than the previous direct burning system, whatever the thermal ratio in the air boiler. This must be so, since, to produce the same turbine inlet temperature and therefore the same output

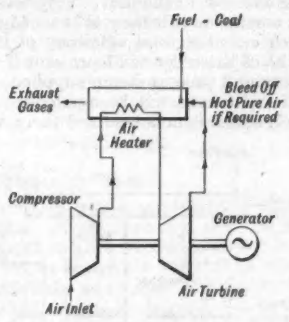


FIG. 3

from the turbine, more fuel must be burned to balance the flow of heat with the flue gases. It may be that the paper manufacturer can make use of a large amount of hot, clean air for drying purposes. However, it seems that in general he prefers to use steam for heating the inside of the drying cylinders, digestion of pulp and other processes. The reason for this is simply that steam has a far higher heat content, by reason of its latent heat, than that of air of the same temperature. Not only that, but it parts with this heat much more readily. For the moment, therefore, let us consider other means of improving the cycle efficiency.

If the hot exhaust air from the turbine is used to feed the furnace, then less heat will be required to give the desired turbine inlet temperature. This arrangement is shown in Fig. 3.

Efficiencies

The efficiency of this cycle as a power producer is shown in Fig. 4. It is definitely better than the first indirect heating scheme, having a peak thermal efficiency in the region of 15 per cent with a turbine inlet temperature of

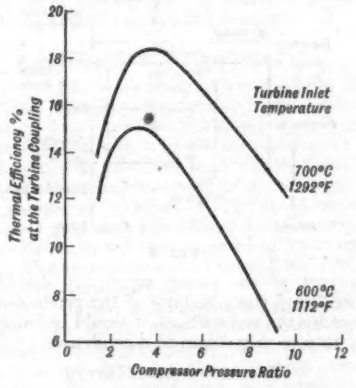


FIG. 4

600 deg. Cent. Another good effect to be derived from this scheme is that the pressure ratio of the cycle is much reduced since this is in effect a heat exchanger scheme. With the simple cycle, the peak efficiency occurs at a pressure ratio of some 6·0 : 1, whereas with this scheme the optimum ratio is about 3·5 : 1. This means that the cost of the plant will be reduced.

It is as well now to consider the effect of varying the turbine inlet temperature. Also shown in Fig. 4 is the efficiency of the same cycle with the turbine inlet temperature raised to 700 deg. Cent. The thermal efficiency corresponding to this rises to 18 per cent. By complicating the cycle with items such as splitting the compression and expansion and introducing intercooling and reheat, this efficiency can be considerably enhanced.

About 74 per cent of the heat energy supplied (cycle Fig. 3) by the fuel must be passing out

* Paper read at Conference of British Paper and Board Makers' Association, Edinburgh. October 24th. Abstract.

† Managing director, Power Jets (Research and Development), Ltd.

from the exhaust. In fact, on the basis of the assumptions made, the exhaust temperature is about 350 deg. Cent. (662 deg. Fah.); thus, it is quite feasible to recover a proportion of this heat in some kind of waste heat boiler. The amount of recovery of heat from the exhaust in such a boiler will depend in large measure on the surface area furnished and therefore on the size and cost of the unit. Very tentatively, we can assume an efficiency of some 45 per cent, in which case the total efficiency of the cycle would be of the order of 51 per cent if we total up power and process steam supplied. At the same time, it must not be overlooked that on the basis of the figures assumed there will be a

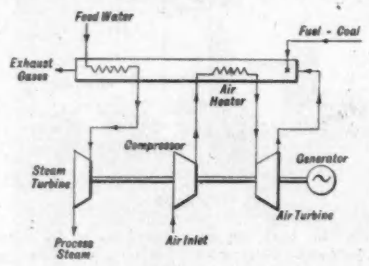


FIG. 5

definite relationship between the power supplied and the process steam supplied. In fact, for every 1000kW of power we shall have roughly 5700 lb per hour of steam at 30 lb per square inch and 15 deg. Fah. superheat. The ratio of power to steam heat will vary with the turbine inlet temperature and the heat extractions of both the air heater and the waste heat boiler though it is unlikely that the possible variation is going to be sufficient to satisfy all plants. Furthermore, the total thermal efficiency is not the best that can be obtained, although the result can be improved by raising the efficiency of the waste heat boiler. In the unlikely event of more electrical power being required in relation to the processed steam than this scheme is capable of giving, we can arrange for it by incorporating a back-pressure turbine in the process steam supply line (see Fig. 5). Although this means that we shall be back to the familiar schemes for

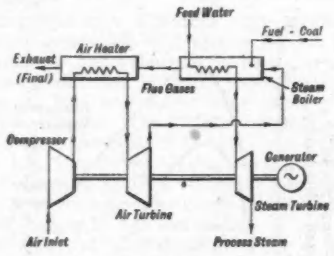


FIG. 6

this part of the power supply, it should be remembered that, because of the production of power by the gas turbine, it would be unnecessary to pass any steam to a condenser.

Practical Application

The difficulty with the foregoing scheme, exemplified in Fig. 5, is that the thermal efficiency of the cycle is restricted by the high-temperature limitations of the air heater and turbine. It will be observed that, in one sense, the steam boiler and the air heater are really "playing out of position," in that the air heater is subjected to the high gas temperatures, whereas the steam boiler operates at much lower exhaust temperatures. By reason of the better heat transmission from steam, the tube temperatures in a steam boiler are more nearly approaching those of the steam than of the gas, whereas in an air boiler the reverse is the case. Consequently, in the schemes considered, apart from questions of efficiency, the air heater might very easily be the stumbling block. In any case, it is certain that expensive materials would have to be used in its construction which could well put the scheme out of court. There does appear to be a solution, however, which has certain attractive features.

If the position of the air heater and boiler are reversed in the schemes considered, we then have the situation that it is the steam boiler that gets the high-temperature gas, whereas the air heater gets the gas exhaust at a much lower temperature (Fig. 6). Thus, both units would be operating in conditions that experience has already shown us they can handle. An approximate estimate of the total thermal efficiency of the cycle in Fig. 6 has been carried out, but without using a steam turbine (that is, all steam to process). The following figures, together with reasonable practical pressure losses in the system were used in the estimate :—

Higher calorific value of coal... ...	12,000 B.Th.U./lb
Air/coal ratio in boiler	20 : 1
Air heater thermal ratio	80 per cent
Axial compressor efficiency (polytropic)	86 per cent
Gas turbine efficiency (polytropic)...	86 per cent
Turbine inlet temperature	700 deg. Cent (1292 deg. Fah.)

Using these assumptions it was found that the total thermal efficiency was approximately 75 per cent. The boiler efficiency required was

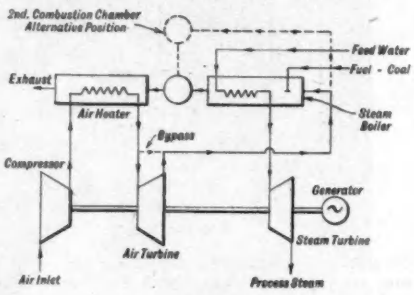


FIG. 7

found to be about 70 per cent. For 1000kW of power the process steam supply at 30 lb per square inch gauge and 15 deg. Fah. superheat would be about 32,000 lb per hour. This ratio of power to steam supply could, of course, be raised by putting in the steam turbine as shown in Fig. 7.

As the scheme stands in Fig. 6 we should have the position that as one item is reduced so is the other. To overcome this, it is suggested that we put in a second combustion chamber as shown in Fig. 7. Alternative situations are shown for this combustion chamber. If steam requirements fell in relation to power requirements, then the fuel supply to the boiler could be reduced and the power maintained or increased by burning fuel in the second combustion chamber.

The basic idea of combining steam and gas turbines seems to have interesting possibilities for waste heat users.

In certain paper mills—particularly, it seems, in small ones—it has been found economically advantageous to use diesel engines to generate the power and to use steam boilers merely to raise the steam. If a straight gas turbine with direct oil burning and without a heat exchanger were to be used instead of a diesel engine, then we could gain two advantages. First, we should have a lower capital cost and could use the turbine exhaust to supply hot gases to the furnace. It is not possible to do the latter with a diesel engine, but in a gas turbine only about one-fifth of the oxygen would be removed, leaving four-fifths to carry on the coal combustion. It is true that the simple gas turbine would burn about twice as much oil as would the diesel, but, whereas the diesel would throw away some 60 to 65 per cent of its heat in jacket water heating and exhaust, the gas turbine would pass all its waste heat to the furnace with considerable saving in coal.

This type of plant would only find its application in cases where the power required did not exceed a certain amount in relation to the process steam required. For instance, a simple gas turbine giving about 500kW would exhaust about 13 lb per second of air and gas at a temperature of, say, 400 deg. Cent. (752 deg. Fah.). In this, we could burn perhaps 2000 lb per hour of coal yielding 32,500,000 B.Th.U. to the steam assuming a boiler efficiency of 73 per cent and a heating value for the coal of 12,000 B.Th.U. per pound. This heat would generate about 29,000 lb per hour of process steam at 30 lb per square inch gauge and 15 deg. Fah. of superheat. To make a considerable variation in this ratio, we should have to modify the arrangement in some way, and would probably arrive back at something closely approaching the arrangement in Fig. 6, not necessarily with the steam turbine, but with an oil-burning combustion chamber as the main supply of heat to the gas turbine. Prior to the combustion chamber there would be a heat exchanger in the flue gases of the steam boiler.

American Engineering News

(From our American Correspondent)

A Monorail Overhead Transport System for Los Angeles

The Governor of the State of California recently signed a bill authorising the formation of a Los Angeles Metropolitan Transit Authority, with power to build and operate a monorail overhead transportation system for the relief of traffic congestion in metropolitan Los Angeles. The proposed monorail system would follow the Los Angeles River bed between the San Fernando Valley and Long Beach and would extend over 44 miles. It would consist of two rails—one for incoming and the other for outgoing trains—mounted on "V"-shaped steel supports, to be spaced approximately 70ft apart. The carriages, suspended on two wheels each, would run singly or together in trains of up to five. They would travel 16ft above the ground, rising occasionally to clear obstructions or dipping under a bridge. The carriages would be propelled by electric motors, encased in the wheel mountings, at an average speed of 38·1 m.p.h. Concave rollers mounted on the top of each carriage have been designed to prevent derailment at speeds up to 55 m.p.h. It is intended that passengers, served by feeder bus lines, would board the monorail by escalators and pay their fares at turnstiles. The technical and commercial development of the scheme is being handled by two affiliated private organisations, the Monorail Engineering and Construction Corporation, which is concerned with the actual construction of the system, and the Southern California Monorail and Transit System, Incorporated, which was organised to promote the monorail plan until the transit authority can take over. The total cost of the proposed system is estimated at between 60,000,000 and 80,000,000 dollars for the route described. It would make the cost per mile about 1,500,000 dollars, compared with an estimated 10,000,000 dollars a mile for an underground railway.

U.S. Reclamation Engineering Services for India

A formal agreement has been concluded between the Governments of the United States and India, whereby the U.S. Bureau of Reclamation will give advice and scientific and technical engineering service in the United States to the Indian Government. The agreement, which was completed with the aid and advice of the State Department, provides for direct communication between the U.S. Commissioner of Reclamation and the Indian Waterpower, Irrigation and Navigation Commission in the handling of technical engineering matters. Under the agreement, the personnel and laboratory facilities of the Bureau at its Denver Engineering Centre will be made available to assist the Indian Government with water development problems. The services to India will include the study and analysis of scientific and technical engineering data, testing of materials for dams, analyses of stresses and stability involving technical studies, construction and testing of hydraulic models, and advisory services. They will also include services and advice, if required, to determine the adequacy of the designs or construction. The services will not include project construction, direct supervisory work and the preparation of detailed project construction, design or specification drawings.

Industrial and Labour Notes

British Overseas Trade

The final figures relating to Britain's overseas trade in October have now been published by the Board of Trade, and show that the value of exports of United Kingdom products reached a record figure of £235,300,000, compared with an average of £218,600,000 in the third quarter of this year. But, as noted in our last issue, October was a long working month and the rate of export was only about 2 per cent above the third quarter level. In volume, October exports are estimated to have been about 6 per cent higher than the average for the third quarter, or roughly the same if allowance is made for the longer month.

October exports of metals and engineering products were valued at £110,200,000, the most marked increase in these groups being vehicles. The value of vehicle exports, which include locomotives, ships, aircraft and road vehicles, was £45,500,000, or about £7,000,000 above the average for the third quarter. The number of motor-cars exported in October was 32,307, which was 16 per cent above the third quarter average. The increase in October, the Board of Trade says, was largely brought about by a recovery in motor-car exports to Australia, which numbered 11,532, compared with an average of 8056 in the third quarter. The quantity of iron and steel exported in October was 210,000 tons, which was an amount 7 per cent above the average level of the third quarter, but nearly one-fifth below the monthly average for 1950. The quantity of coal exported in October—953,000 tons—was substantially higher than in any other month this year.

Exporting to the U.S.A.

The Board of Trade has issued a new booklet entitled *Exporting to the United States of America*. It has been compiled with the assistance of the Consular Department of the British Embassy in Washington, and although it is not an economic survey in the general sense, it does set out some of the more immediate and practical problems facing exporters.

The booklet gives a brief outline of the main points about United States markets, the problems associated with selling goods in them, and some suggested methods of approach. Among its seven chapters there is one dealing with current American Government regulations and another which refers to the advantages offered to exporters in various American trades. Other chapters deal with the characteristics of American markets, selling and distribution, and methods of sales promotion. This last chapter mentions specifically such matters as advertising, packaging, trade literature, and participation in exhibitions and fairs. There is also some information on the special facilities offered by the Export Credits Guarantee Department to United Kingdom exporters.

The booklet is obtainable from H.M. Stationery Office, Kingsway, London, W.C.2, at 2s. 6d.

Non-Ferrous Scrap Metal Collection

The Ministry of Supply has announced that non-ferrous scrap metal during the past year has provided a higher proportion of the country's requirements than in 1950. The high level of consumption has been maintained by running down of stocks, and it is considered to be of vital importance that industry should now dispose of every available piece of non-ferrous scrap. At present copper scrap forms 41 per cent of total consumption, lead 50 per cent, and zinc 35 per cent. This represents an increase of 4 per cent in copper and 7 per cent in zinc as compared with 1950. It is pointed out that prices obtainable for such scrap vary according to quantity and quality, but the following prices are quoted as a rough guide: aluminium, 70s. to 80s.; brass, 140s. to 160s.; copper, 160s. to 200s.; gunmetal, 160s. to 200s.; lead, 140s. to 150s.; and zinc, 120s. to 130s. per hundredweight. Although the high prices have already brought out most of the scrap metal at the disposal of industry, it is considered probable that there are still redundant stocks of components and obsolete plant about the country, and it is hoped that further efforts will be made to turn them over to scrap dealers without delay.

Steel Rationing

Control of the distribution of alloy and non-alloy (carbon) steel will begin on February 4, 1952, and the new arrangements will be similar to those in operation up to May, 1950. Under this control no person may from February 4th next—with certain exceptions under a small quantities exemption clause—acquire or use specified kinds of steel without an authorisation. Such an authorisation will permit a consumer to acquire steel direct or allow his sub-contractors to purchase steel. Any consumer (except a sub-contractor) who requires steel in the controlled forms and who has not yet stated his requirements to the appropriate department should apply at once to the department normally dealt with on matters of production. Small consumers, it is pointed out by the Ministry of Supply, whose requirements are 25 tons or less a quarter, including not more than 10 tons of sheets, should apply to the regional controller of the Ministry. In cases of doubt application should be made to the M.O.S. Iron and Steel Division, Shell-Mex House, Strand, London, W.C.2. The new Order covers alloy as well as non-alloy steel and consumers will receive separate authorisations for each kind as well as for sheet and tinplate. Iron and steel stockholders will again need licences to acquire controlled kinds of steel for re-sale.

Census of Production for 1951

The Board of Trade has made an Order indicating the scope of the Census of Production to be taken in 1952 for the year 1951. Undertakings producing coal, gas, electricity, oil shale, crude or refined petroleum or shale products are exempted from making returns to the extent to which they supply the necessary information to the Ministry of Fuel and Power. Copies of the Order, which operates from December 31, 1951 can be obtained from H.M. Stationery Office. The Board has also published a list giving the names of the members of the statutory advisory committee to advise it when considering the preparation of forms and instructions for the census to be taken in 1953.

Accidents in Industry

In connection with the series of lectures on the worker in industry, arranged by the Ministry of Labour, a paper on "The Human Factor in Accident Prevention" was read at Birmingham last week by Professor T. U. Matthew, of the Department of Engineering Production of the University of Birmingham. He said that the total loss to the nation as a result of accidents in the mining, manufacturing and building industries might well be in the region of £150 million a year. He emphasised the responsibility of the human factor for accidents and said that even to-day apathy, indifference and suspicion made it difficult for management and workers to co-operate effectively in the introduction of new and improved safety measures. In urging the appointment of more trained safety officers, the professor said that industry might well save half the man-hours now lost because of industrial accidents.

In connection with the statements made by Professor Matthew it is of interest to note that last week Sir Alfred Herbert sent a note to all sections of the Press in this country dealing with foot injuries in industrial establishments. He points out that, unlike most other accidents, there is a definite preventive available for feet in the form of safety boots with internal steel toecaps. By using such safety boots in his own company's workshops in Coventry foot accidents were reduced from eighty-nine in 1943 to seventeen in 1950.

Engineering Wages

When the general council of the Confederation of Shipbuilding and Engineering Unions met at York on Wednesday of last week, it decided to accept the offer of an increase of 11s. a week for adult male workers in the engineering industries. As recorded in these notes last week, the offer was made by the Engineering and Allied Employers' National Federation as the response to a claim submitted by the unions for an increase of £1 a week. The Employers' Federation also offered an extra week's holiday with pay, which the council of the Confederation decided to accept. It has been stated that the offer will add about £85,000,000 to the annual wages bill of the engineering industries.

Employment in the Engineering Industries

The Minister of Labour, Sir Walter Monckton, was asked in Parliament last week if he was aware of increasing redundancy and under-employment in certain of the engineering industries, and also what action he was taking to absorb into productive employment the labour made available. In his reply, the Minister said that the latest information available to him did not suggest any substantial increase of redundancy or short-time working in the engineering industries. The demands of engineering firms for labour far exceeded the number of workers available, and there was no difficulty or delay in finding other employment for the small numbers becoming redundant. The Minister added that, so far as his information went, there was no difficulty at present in placing skilled engineering workers.

Coal Supplies in Europe

The coal trade sub-committee of the United Nations Economic Commission for Europe has recently announced that Europe's probable coal deficit in the first quarter of 1952 is likely to be 8,800,000 tons. That, it has been stated, is an improvement of about 8 per cent on the probable deficit of 9,500,000 tons in the current quarter. For coke, it is estimated that the deficit in the first quarter of 1952 will be 2,000,000 tons, compared with 2,500,000 tons in the present quarter.

The Commission is careful to point out, however, that whilst these provisional estimates indicate an improvement in the solid fuels position in Europe, the situation remains serious. The improvement, it is suggested, is the result of a substantial decrease in the import requirements of several countries. It more than offsets an expected slight decrease in the total quantities available for export from the principal European coal producing countries.

Load Shedding

The Minister of Fuel and Power, Mr. Geoffrey Lloyd, stated in Parliament on Monday last that, in the circumstances facing the country this winter, it was economy in the use of electricity during the peak hours that could help most to minimise load shedding. He thought that the greatest practicable step which could be taken in that direction was the organisation of systematic load spreading by large industrial and commercial undertakings. The regional boards for industry were making arrangements for those consumers to reduce their peak hour demands by at least 20 per cent.

Notes and Memoranda

Rail and Road

MOTOR-CYCLE SPECIFICATIONS. — A booklet entitled *British Motor Cycles*, 1952, being the second edition of this reference, has been published by Stone and Cox, Ltd., 44, Fleet Street, London. This descriptive handbook contains detailed specifications of 170 British motor-cycles, most of which are illustrated, and amongst them are the most recent models shown at Earls Court. The booklet is divided into sections devoted to light-weight models, power units for cycles, standard tourers with greater than 200c.c. capacity, racing models and there is a section dealing with three-wheelers.

CAR EXPORTS—The Society of Motor Manufacturers and Traders states that British car exports in October were the highest on record and amounted to £11·4 million. The export of agricultural tractors was also the highest on record and stood at £4·4 million for the month.

Air and Water

SHIP GRAVITY DAVITS.—The Marepa design of gravity davits for ships' lifeboats will be manufactured and sold by J. Stone and Co. (Charlton), Ltd., under the name Stone-Marepa, the company having acquired an exclusive licence from the Marepa Trust, Ltd.

MARINE GAS TURBINE.—The oil tanker "Auris," belonging to the Anglo-Saxon Petroleum Company, Ltd., has completed the outward voyage to Port Arthur, Texas, and the gas turbo-alternator, which was recently installed, ran continuously throughout the twenty-one-day voyage.

RIVER TYNE IMPROVEMENTS.—The Tyne Improvement Commission intends to ask for further borrowing powers of £1,000,000, permission to mate the Northumberland Dock tidal and to be relieved of the obligation to maintain Whitehill Point ferry. In agreement with the National Coal Board, the Commissioners have decided to close down the coaling staithes in the Northumberland Dock and to erect new staithes at Whitehill Point.

AERONAUTICAL TERMS AND UNITS.—We have received from the Society of British Aircraft Constructors, Ltd., a booklet containing English and French translations of aeronautical terms and units. The difficulties which exist in the translation of aeronautical terms and units from ordinary technical dictionaries are well known and, apart from its main contents, this excellent reference contains common abbreviations and arithmetical conversion factors.

ASSOCIATION TECHNIQUE MARITIME ET AERONAUTIQUE.—We have received from the Association Technique Maritime et Aeronautique, 1, Boulevard Haussmann, Paris, 9, a copy of the 1951 edition of the Association's Year Book, which includes the rules, list of members and of all the papers read since 1890. In a final section the papers which have been read at all the annual congresses, generally held in Paris in June, over the period 1923 to 1951, have been analysed and are listed under classified subject headings in French and English. Among the papers read at the 1951 congress were: "Standardisation of Screw Propellers," "Recording of Hull Vibrations with the Propelling Machinery at Rest," "The Influence of Hull Form and Rudder Shape on Canal Navigation—Model and Full-scale Comparisons," "The Gas Turbine Operated in Conjunction with Steam Boilers," and "Trim, Stability and Heel of Damaged Ships."

Miscellanea

STROBOSCOPES.—The Magna Jobson Research Centre has issued a booklet entitled "Some Notes on the Stroboscope," which deals in particular with the Ashdown Rotoscope. This instrument, which depends on a special shutter or "sight gear" principle, is described in some detail. One model has a speed range 500 to 20,000 "glimpses" per min., which can be increased to 40,000 per min. by the use of a "displacement" shutter instead of the standard shutters.

CONSENT FOR NEW 600MW POWER STATION.—The British Electricity Authority has received the consent of the Minister of Fuel and Power to the establishment of a new 600MW power station at Castle Donington, near Derby. The authorisation covers the complete installation of the station, which will comprise six 100MW turbo-alternator sets, six boiler units, each of an evaporative capacity of 830,000 pounds of steam an hour, and four cooling towers, each having a capacity of approximately 4½ million gallons of water an hour. The first set is planned to be in commission by the winter of 1955 and it is provisionally contemplated that the whole station will be running by 1960.

ROYAL SOCIETY MEDALLISTS.—The following awards of medals have been made by the president and the council of the Royal Society: the Copley Medal to Professor D. Keilin, F.R.S., for his fundamental researches in the fields of protozoology, entomology and the biochemistry of enzymes; the Davy Medal to Sir Eric Rideal, F.R.S., for his distinguished contributions to the subject of surface chemistry; the Hughes Medal to Professor H. A. Kramers, for his distinguished work on the quantum theory, particularly its application to the optical and magnetic properties of matter.

NEW DISTILLATION UNIT.—Last March, the chairman of the Manchester Oil Refinery, Ltd., Mr. H. Stuart Ebben, announced that the throughput of the refinery, which reached a rate of 115,000 tons per annum in 1950–51, would be increased to an annual rate of 150,000 tons. The expansion programme has been put in hand and construction of a new atmospheric distillation unit with a capacity of 3500 barrels per day, is well advanced. Consisting mainly of a fractionating tower, 120ft high, the new unit will work in conjunction with the existing vacuum distillation plant and extend the range of M. O. R. products by producing white spirit and other petroleum solvents in addition to petrol.

COAL GASIFICATION EXPERIMENTS.—The Minister of Fuel and Power, Mr. Geoffrey Lloyd, was questioned in Parliament on November 12th about the position of underground coal gasification experiments being conducted by his department. In a written answer, the Minister said that the experimental work was being continued at Newman Spinney, near Sheffield, and that preparations for experiments were being made at Bayton, Worcestershire, where it was expected that two coal seams would be ignited early in 1952. The reply pointed out that the experiments were on a relatively small scale, designed to discover the technical and economic facts necessary to determine whether a full-scale operation should be planned.

FINNED TUBE.—The Spiral Tube and Components Company, Ltd., of Osmaston Park Road, Derby, has issued a book entitled *Finned Tube*, which is intended to fill a gap in the literature available to users of heat transmission plant. The book is an original factual treatise on the subject and provides authoritative and valuable information to engineers who may encounter problems of design or installation of industrial plant which incorporates finned-tube heat transmission units. It covers all aspects of the subject and gives a working knowledge of the principles governing the performance of this kind of equipment as well as helpful guidance upon the correct installation and use. The company informs us that the book will be sent gratis to engineers and institutions making official application to the above offices.

THE N.C.B. NATIONAL PLAN.—At a recent meeting of the Coal Industry National Consultative Council, Sir Hubert Houldsworth, chairman of the National Coal Board, stated that the Minister of Fuel and Power had formally approved the Board's long-term plan. In granting his approval the Minister had assumed that the plan was primarily an indication of the general lines on which the development of the mining industry was expected to take place, submitted to him only in broad outline so as to preserve flexibility in executing reorganisation and development plans and in the changing circumstances likely to be encountered over the period of years envisaged. The Minister also emphasised to the Board that the rate at which the plan is executed and the amount of investment undertaken each year must necessarily depend upon decisions taken by the Government on investment policy, the supply of materials and on employment and social considerations.

THE F. B. RICHARDS EQUIPMENT FUND.—To mark the retirement of Mr. F. B. Richards from the chairmanship of the Woodall-Duckham group of companies after nineteen years' service in that capacity, the directors of the Woodhall-Duckham Vertical Retort and Oven Construction Company (1920), Ltd., have arranged to make a grant of £1000 a year under a seven-year covenant to create an equipment fund for the Department of Coal Gas and Fuel Industries with Metallurgy at Leeds University. The capital from the fund will be utilised by the Livesey Professor at his discretion for the purchase of equipment for his department. In expressing its appreciation of this gift, the University has suggested that the fund should be known as the "F. B. Richards Equipment Fund." Mr. Richards was for many years a member of the Coal Gas and Fuel Industries (Livesey Professorship) Committee of Leeds University and took a considerable interest in the success of the Fuel Department.

GREY IRONFOUNDING PRODUCTIVITY SUMMARY.—The response to the offer by the Council of Ironfoundry Associations of free supplies of the summary of the Grey Ironfounders' Productivity Team's Report has been very encouraging. Up to date 588 firms have taken advantage of the offer by distributing a total of 56,000 copies to iron foundry employees. Supplies are still available to any iron foundry management wishing to distribute this illustrated popular version of the productivity report to foundry workpeople. They can be obtained from the Secretary, The Council of Ironfoundry Associations, Crusader House, 14, Pall Mall, London, S.W.1.

Personal and Business

MR. W. R. JONES has been appointed chief engineer of Nevelin Electric Company, Ltd.

HOWARD TENENS (SHIPPING), Ltd., has acquired additional factory and storage space at Colchester Avenue, Cardiff.

LONDON TRANSPORT announces the appointment of Mr. A. E. Shave, A.M.I.C.E., A.M.I.Mech.E., as supplies officer.

MR. S. R. HALSEY has been appointed a director of James Gordon and Co., Ltd., Dalston Gardens, Stanmore, Middlesex.

MR. F. FAWCETT, A.M.I.C.E., has been appointed district engineer, Derby (South), in the London Midland Region of British Railways.

PRESTON AND BISHOP, Ltd., 1–4, Broad Street Place, London, E.C.2, has accepted the sole agency for the British Isles for Goetze oil seals.

COMMANDER (E) T. J. TURNER, R.N. ret., A.M.I.Mech.E., has been appointed general manager of Prat-Daniel (Stanmore), Ltd., Stanmore, Middlesex.

THE CLYDE NAVIGATION TRUST announces that Mr. John McLean, the deputy chairman, has been elected chairman in succession to the late Mr. Barclay Hogarth.

BABCOCK AND WILCOX, Ltd., Farringdon Street, London, E.C.4, states that Mr. E. B. Watton, A.M.I.E.E.—lately assistant editor of *Electrical Times*—has joined the publicity department as editorial assistant to Mr. G. M. C. Peacock.

THE EARL OF BALFOUR has tendered his resignation as chairman of the Scottish Divisional Coal Board in order to take up an appointment outside the coal industry. He has consented to serve as a part-time director on the Scottish Divisional Coal Board.

ROCKWELL MACHINE TOOL COMPANY, Ltd., Welsh Harp, Edgware Road, London, N.W.2, states that it has been appointed sole agent in this country for the following German firms: Drabert A.G. Minden; West, Delisle and Ziegele, Stuttgart; Kraumendahl, Lorrach/Baden, and Hartex, Berlin.

Launches and Trial Trips

FRANCE STORE, motor tanker; built by Harland and Wolff, Ltd., for Lorentzen and Co., Oslo; length between perpendiculars 580ft, breadth moulded 78ft, depth moulded 42ft 6in, deadweight 24,000 tons; twenty-seven cargo oil compartments, two pump rooms, steam deck machinery; Harland-Burmeister and Wain two-cycle, eccentric opposed piston oil engine, seven cylinders, 750mm diameter by 2000mm combined stroke, 110 r.p.m., two single-ended multitubular boilers. Trial, November 12th.

LEASOWE, passenger ferry; built by Philip and Son, Ltd., for the Corporation of Wallasey; length between perpendiculars 145ft, breadth moulded 34ft, depth moulded 12ft 3in, load draught 7ft 4in; 1600 passengers carried on ferry service, 700 passengers carried on cruising service; two sets of Crossley direct reversible two-stroke diesel engines, eight cylinders, 10·5in bore by 13·5in stroke, total service power 1200 b.h.p. at 330 r.p.m., 13¾ knots on trial. Trial, November 17th.

BRITISH BULLDOG, oil tanker; built by Swan, Hunter and Wigham Richardson, Ltd., for the British Tanker Company, Ltd.; length between perpendiculars 610ft, breadth moulded 81ft, depth moulded 44ft 6in, deadweight 28,540 tons on 33ft 11¼in draught, fully loaded service speed 15 knots; thirty cargo oil tanks, three 850 tons per hour turbo-driven cargo pumps, two stripping pumps, steam deck machinery; single set of double-reduction geared turbines by Wallsend Slipway and Engineering Company, Ltd., taking steam at 450 lb per square inch and 750 deg. Fah., from two Babcock and Wilcox integral furnace boilers, service power 12,500 s.h.p., maximum power 13,750 s.h.p. at 116 r.p.m. at the propeller. Trial, November 21st.

British Patent Specifications

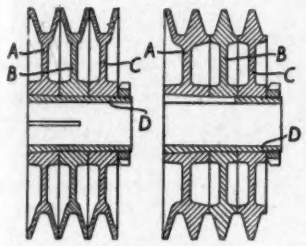
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

POWER TRANSMISSION

658,840. November 9, 1948.—Pulleys for Power Transmission Systems, Sigfrid Linus Stenberg, of Gamlarpsvägen, 15, Nässjö, Sweden.

The accompanying drawings show axial sections of two forms of composite rope pulley in accordance with the invention. *A*, *B* and *C* denote the three annular pulley elements of which the pulley is composed, each element being formed with an individual rope groove. The hub of element *A* has a conical bore, whereas the hub bores of the other elements are cylindrical. The three elements are mounted on a common bushing *D*, the external surface of which is conical over the length covered by the bore of *A*, the remainder within the bores of the other elements are cylindrical. The conically enlarged end of the bushing is formed with one or more slits which preferably extend part way



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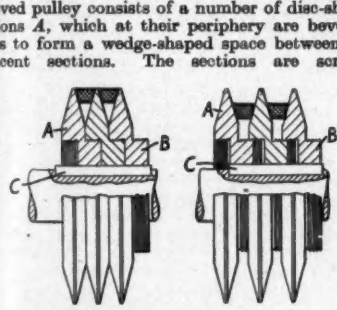
down the cylindrical portion of the bushing. Where the opposite end of the bushing projects beyond the elements it is externally threaded to receive a nut, by means of which the assembly is held together as a unit. In mounting the pulley the bush carrying the elements is pushed on to the shaft, to which it is then locked by tightening the nut. This causes the slit conical portion of the bushing to be forced into the bore of the left-hand element and simultaneously to become clamped around the shaft. While the description is concerned only with grooved pulleys suitable for rope drives, it is understood that the invention is also applicable to pulleys of other types.—*October* 17, 1951.

659,699. September 29, 1949.—V-Belt Pulleys, Bertil Jacobowsky, of Arstavagen 23, Stockholm, Sweden.

As will be seen in the left-hand drawing, the grooved pulley consists of a number of disc-shaped sections *A*, which at their periphery are bevelled, so as to form a wedge-shaped space between two adjacent sections. The sections are screwed



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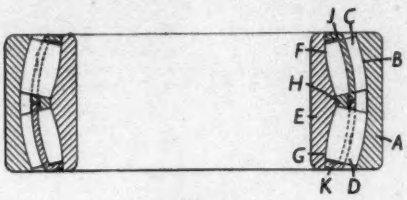
together, each of the discs being provided with a threaded hub *B* and a cylindrical recess, which allows the hub of one section to be screwed into an adjacent section. A key *C* serves two purposes, to lock the sections or discs to the shaft and as a locking means for the threads of the sections or discs to prevent them from being displaced. The pitch diameter for the V-belt or belts may be decreased or increased after the discs have been fitted to the shaft as shown. By this arrangement it is possible to provide a V-belt pulley adapted for one or more pitch diameters of belt.—*October* 24, 1951.

BEARINGS AND SUPPORTS

659,692. September 14, 1949.—Roller Bearings, Aktiebolaget Svenska Kullagerfabriken, 17, Artillerigatan, Goteborg, Sweden.

In the accompanying drawing, which shows a section through one form of a bearing, the outer race ring *A* has an internal spherical race *B* common to both the rows of rollers *C* and *D*. The inner race ring *E* has two races *F* and *G*, one for each row of rollers, the races being concavely arc shaped in profile. The rollers are barrel-shaped and conform closely in profile to the races of the rings. The profiles of their rolling surfaces are convexly curved



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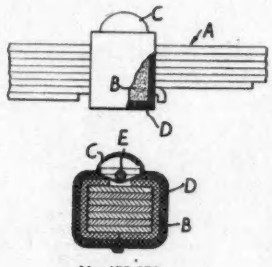
and are symmetrical about the central median planes of the rollers. The rolling surfaces of the rollers are thus symmetrical. A loose guide ring *H* is fitted between the rows of rollers and centred on the inner race ring. The rollers are separated and are guided by cages *J* and *K*, one for each row.

In the specification the advantages claimed for the new design are fully explained.—*October* 24, 1951.

ROAD TRANSPORT

659,570. November 22, 1949.—Lubricators for Vehicle Leaf Springs, Harry Vernon Durose, "Greenlanes," Henley-in-Arden, Warwickshire.

The lubricator, as applied to a vehicle leaf spring *A*, is made up of superimposed laminations, and consists of an inner pad of thick oil-absorbent felt *B*, which extends around the spring so that its ends meet beneath the bottom leaf. This felt pad is pressed against the edges of the spring laminations and is fed with oil from a lubricant reservoir *C*. Through a central hole in the felt layer, above the



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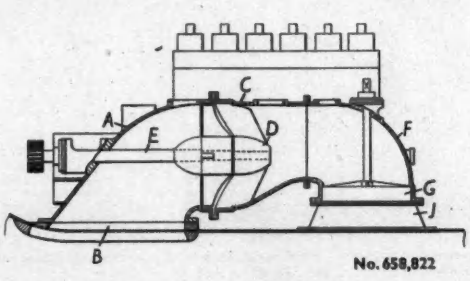
middle of the top leaf, the oil is conducted to the edges of the leaves. The felt layer is almost entirely housed within a flexible channel-sectioned cover *D* of synthetic rubber, impervious to oil. The oil reservoir *C* may contain a ball *E* which normally closes the oil outlet hole, but which is caused to move away from it by vibration or by movement of the vehicle.—*October* 24, 1951.

MARINE ENGINEERING

658,822. April 25, 1949.—Hydraulic Jet Propulsion Apparatus, Gill Propeller Company, Ltd., 17, Victoria Street, London, S.W.1 (*Inventor: James Herbert Wainwright Gill*).

The object of the invention is to provide a form of hydraulic jet propulsion in which the deflector does not project below the hull and its overall diameter can be small in relation to the diameter of its inlet end. In the construction illustrated, the apparatus comprises an inlet passage *A* leading from an opening *B* in the hull of a vessel to the inlet end of an axial-flow pump *C*, the impeller *D* of which is driven through a shaft *E*, and a discharge passage *F* through which the pump delivers the water. The discharge passage terminates in a vertical outlet *G* of circular cross section communicating with and embodying a shaft support for a nozzle member *H* rotatable in a shallow cylindrical recess or housing *J* in the hull of the ship so as not to project below the hull. The nozzle member comprises a short tubular



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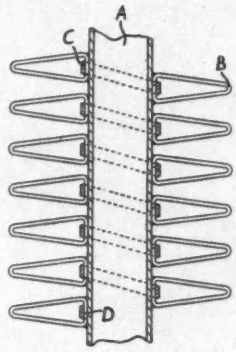
casing *K*, which is of circular internal cross section in all horizontal planes, but having its lower end displaced laterally from its upper end by a distance equal to about one-eighth of its internal diameter while its ends remain in parallel planes. Extending across the tubular casing are a series of guide vanes *L* lying at right angles to the plane in which the curved centre line of the bore of the casing lies. Each vane is curved in conformity with the curvature of that centre line so as to provide a series of contracting passages of wide slot-like form, the water flowing through each being deflected so as to leave it in the desired direction, having a substantial horizontal component.—*October* 10, 1951.

HEAT EXCHANGERS

659,114. March 28, 1949.—Heat Transmitting Tubes, Clayton Dewandre Company, Ltd., Stanley Howard Edge, and Frank William Duncombe, all of Titanic Works, Lincoln.

In the construction described, wire windings are formed around a tube *A*, through which a heated fluid flows. They are made from a continuous length of wire, which is formed first into a continuous series of exactly similar loops *B* on a



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mandrel. On removal from the mandrel the wire is wound on to the tube in a helical formation and secured by a binding wire *C* and soldered in position. The wire windings are formed so that each loop has tapering sides with a comparatively wide base to ensure that a greater area of the wire loop is in contact with the tube wall than in previous arrangements to assist greater heat transfer.—*October* 17, 1951.

GAS TURBINES

659,715. October 28, 1949.—Cooled Gas Turbine Rotor, Aktiengesellschaft Brown Boveri et Cie., Baden, Switzerland.

According to the invention the impurities and the disturbances which are caused thereby are avoided by passing the cooling liquid directly before it enters the gas turbine rotor through a centrifugal purifying device where heavy impurities are

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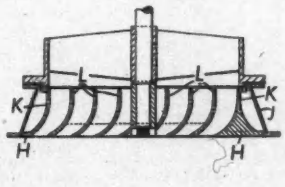
removed. The drawing shows a constructional example of a gas turbine rotor according to one form of the invention. The cooling liquid flows through the stationary pipe *A* into the centrifugal purifier *B*. In this the liquid is given by means of blades *C* a peripheral speed corresponding to the diameter of the casing and in chamber *D* the heavy impurities are separated out and remain behind. By means of blades *E*, which at least partly extend



radially up to the centre of the shaft, the rotational velocity of the cooling liquid is reduced again so that it does not rotate relative to the rotor shaft when leaving the hollow shaft. The impurities which are separated out in the purifier can be removed as desired through the cleaning openings *F*. The purified cooling liquid flows through the shaft bore to the gas turbine rotor. The vapour which is produced from the cooling liquid passes through the hollow shaft at *G* and then at *H* through a discharge casing.—*October* 24, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Association of Supervising Electrical Engineers

Mon., Dec. 3rd.—LEEDS BRANCH: Great Northern Hotel, Wellington Street, Leeds, 1, "Industrial Electronics," A. G. Hickman, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, "Problem Night," 8 p.m.——SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "Electricity in the Steel Works," F. L. Parkin, 7.30 p.m.

Tues., Dec. 4th.—W. LONDON BRANCH: Windsor Castle Hotel, 134, King Street, Hammersmith, W.6, "Lead Acid Batteries and their Applications," V. A. Lord, 7.30 p.m.

Wed., Dec. 5th.—N. LONDON BRANCH: Three Jolly Butchers' Hotel, Wood Green, N.22, "Phenolic Moulding Materials," B. T. Francis, Film, "The Material of Infinite Uses," 8.15 p.m.——YORK BRANCH: Feasgate Restaurant, Feasgate, York, "Aluminium Sheathed Cables," F. Aldridge, 7.30 p.m.

Thurs., Dec. 6th.—S. LONDON BRANCH: Cafe Royal, North End, Croydon, "The I.E.E. Regulations," S. J. Emerson, 8 p.m.

Birmingham Association of Mechanical Engineers

Fri., Dec. 7th.—James Watt Memorial Institute, Great Charles Street, Birmingham, "Metallurgical Inspection," E. Wood, 7 p.m.

Electric Railway Society

Sat., Dec. 1st.—Fred Tallant Hall, Drummond Street London, N.W.1, Annual General Meeting, 3 p.m.

Engineers' Guild

Thurs., Dec. 6th.—Caxton Hall, Caxton Street, Westminster, S.W.1, Films, "The Port of Manchester," and "Voices Under the Sea," 6 p.m.

Illuminating Engineering Society

Tues., Dec. 4th.—CARDIFF CENTRE: South Wales Electricity Board, Cardiff, "Lighting of the New House of Commons," C. Dykes Brown, 5.45 p.m.——LIVERPOOL CENTRE: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "Whither Gas Lighting," G. W. A. Illingworth, 6 p.m.——STOKE-ON-TRENT GROUP: 31, Kingsway, Stoke-on-Trent, "Shop and Store Lighting," A. W. Jervis, 6 p.m.

Wed., Dec. 5th.—NEWCASTLE CENTRE: Minor Durrant Hall, Oxford Street, Newcastle upon Tyne, 1, "Black Light: Its Effect and Application," H. L. Privett, 6.15 p.m.

Thurs., Dec. 6th.—NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, "The Design and Development of New Lighting Fittings," L. W. V. Turner, 5.30 p.m.——EXETER GROUP: Providence Hall, Northernhay Street, Exeter, "Lighting for the Prevention of Industrial Accidents," E. W. Murray, 7 p.m.

Fri., Dec. 7th.—BATH AND BRISTOL CENTRE: S.W. Electricity Board Lecture Theatre, Colston Avenue, Bristol, "Lighting for the Prevention of Industrial Accidents," E. W. Murray, 6.15 p.m.——BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, "The Architects' Approach to Artificial Lighting," R. G. Cox, 6 p.m.——HUDDERSFIELD GROUP: Electricity Showroom, Market Street, Huddersfield, "Lighting in the New House of Commons," C. Dykes Brown, 7.15 p.m.

Incorporated Plant Engineers

Tues., Dec. 4th.—Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Soil Mechanics," Mr. Wilson, 7 p.m.——S. WALES BRANCH: Institute of Engineers, Park Place, Cardiff, "Design, Construction and Maintenance of Modern Concrete Mixers," R. Morris-Prosser, 7.15 p.m.

Wed., Dec. 5th.—SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "The Selection of Motors and Switchgear," 7.30 p.m.

Thurs., Dec. 6th.—PETERBOROUGH BRANCH: Demonstration Theatre, Church Street, Peterborough, "Fire Prevention for Engineers," 7.30 p.m.

Institute of British Foundrymen

Sat., Dec. 1st.—WALES AND MONMOUTH BRANCH: Engineers' Institute, Cardiff, "Patternmaking for General Engineering Castings," H. S. W. Brittain, 6 p.m.

Institute of Industrial Supervisors

Wed., Dec. 5th.—LEICESTER SECTION: County Mining and Technical School, Nuneaton, "Management and Supervision," S. Waugh, 7.30 p.m.——BIRMINGHAM SECTION: College of Technology, Suffolk Street, Birmingham, "American Foremanship Report," W. J. Izzard, 7.30 p.m.

Thurs., Dec. 6th.—LEEDS SECTION: Great Northern Hotel, Leeds, "The Effect of Costs Upon Industrial Supervisors," F. M. W. Hird, 7.30 p.m.

Institute of Marine Engineers

To-day, Nov. 30th.—Technical College, Barrow-in-Furness, "The Construction of Oil Tankers," H. Armstrong, 7.30 p.m.

Institute of Metals

Tues., Dec. 4th.—S. WALES LOCAL SECTION: University College, Metallurgy Department, Singleton Park, Swansea, "The Solidification of Castings," R. W. Ruddle, 6.30 p.m.

Fri., Dec. 7th.—SHEFFIELD LOCAL CENTRE: The University, St. George's Square, Sheffield, "Precious Metals in Industry," H. G. Dale, 6.30 p.m.

Institute of Road Transport Engineers

Mon., Dec. 3rd.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Transmission," 7.30 p.m.

Tues., Dec. 4th.—EASTERN GROUP: 60, Cremorne Lane, Norwich, "The Use of Lightweight Sandwich Materials in the Construction of R.T. Vehicles," F. C. Lynam, 6.15 p.m.

Institution of Chemical Engineers

Sat., Dec. 1st.—N.W. BRANCH: Radiant House, Bold Street, Liverpool, "Study of Carbide Furnace Operation," R. B. Peacock, 2.30 p.m.——MIDLANDS BRANCH: The University, Edmund Street, Birmingham, "The Design and Performance of Cyclone Separators," C. J. Stairmand, 3 p.m.

Tues., Dec. 4th.—Geological Society, Burlington House, London, W.1, "The Design of Process Equipment with Special Hygienic Requirements," J. Matthews, H. F. Goodman and G. H. Botham, 5.30 p.m.

Institution of Civil Engineers

To-day, Nov. 30th.—YORKSHIRE ASSOCIATION: Blue Bell Hotel, Scunthorpe, "Civil Engineering Aspects of Major Plant Developments at the Appleby-Frodingham Steel Company," K. Patterson, 6.30 p.m., preceded by a visit to the works of the Appleby-Frodingham Steel Company in the afternoon.

Institution of Electrical Engineers

Sat., Dec. 1st.—N. MIDLAND, STUDENTS' SECTION: Yorkshire Electricity Board Offices, Ferensway, Hull, "The Control of Electricity Supplies to Oil Refineries,, G. Auton, 2.30 p.m.

Mon., Dec. 3rd.—Savoy Place, London, W.C.2, Discussion on "Are Sales Engineer-Representatives Necessary?" opened by R. B. Fairthorne, 5.30 p.m.——S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Sutton Coldfield Television Broadcasting Station," P. A. T. Bevan and H. Page; "The Vision Transmitter for the Sutton Coldfield Television Station," E. A. Nind and E. McP. Layton, 6 p.m.

Tues., Dec. 4th.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, Discussion on "The Servicing of Electrical Instruments in Large Industrial Undertakings," opened by A. J. Young, 5.30 p.m.

Wed., Dec. 5th.—RADIO SECTION: Savoy Place, London, W.C.2, "An Investigation in the Mechanism of Magnetic-Tape Recording," P. E. Axon, 5.30 p.m.——SCOTTISH CENTRE: Heriot-Watt College, Edinburgh, "The Effect of Friction on the Behaviour of Servo-Mechanisms at Creep Speeds," J. G. L. Michel and A. Porter, 7 p.m.——N.E. STUDENTS' SECTION: Grey Hall, King's College, Newcastle upon Tyne, "Electrical and Other Means of Ship Propulsion," R. A. Hore, 6.30 p.m.

Thurs., Dec. 6th.—Savoy Place, London, W.C.2, "Technical Colleges and Education for the Electrical Industry," H. L. Haslegrave, 5.30 p.m.

Institution of Engineering Inspection

Tues., Dec. 4th.—COVENTRY BRANCH: Technical College, Coventry, "Ignition and Spark Plugs," M. Rossman, 7.30 p.m.——S.W. BRANCH: Grand Hotel, Bristol, "Nuclear Physics," Dorothy Hawkins, 7.30 p.m.

Wed., Dec. 5th.—BIRMINGHAM BRANCH: Chamber of Commerce, 95, New Street, Birmingham, "Productivity," C.O.I. Films, introduced by Douglas Cranston, 7.30 p.m.——LEEDS BRANCH: Golden Lion Hotel, Lower Briggate, Leeds, Paper and films arranged by the Esso Petroleum Company, Ltd., 7.30 p.m.

Thurs., Dec. 6th.—Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Strain Gauges," W. J. Bunyan, 6 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tues., Dec. 4th.—39, Elmbank Crescent, Glasgow, "The Manufacture of Steel Chains and Slings," W. G. Biggart, 6.30 p.m.

Institution of Mechanical Engineers

To-day, Nov. 30th.—Storey's Gate, St. James's Park, S.W.1, "Cup Drawing from a Flat Bank: An Experimental Investigation," S. Y. Chung, 5.30 p.m.——SCOTTISH BRANCH: Robert Gordon's College, Aberdeen, "Some Milestones in a Hundred Years of Marine Engineering," Edward L. Denny, 7.30 p.m.

Mon., Dec. 3rd.—N.E. BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, "Steam Piping for High Pressures and High Temperatures," R. W. Bailey, 6 p.m.——DERBY A.D. CENTRE: Rolls-Royce Welfare Hall, Derby, "The Aviation Engine," F. R. Banks, 6.15 p.m.

Tues., Dec. 4th.—GRADUATES' SECTION: Storey's Gate, St. James's Park, London, S.W.1, "Steam Refrigeration," J. B. Gray, 6.30 p.m.——COVENTRY A.D. CENTRE: Craven Arms Hotel, High Street, Coventry, "Independent Rear Suspension," Donald Bastow, 7.15 p.m.

Wed., Dec. 5th.—SOUTHERN BRANCH: GRADUATES' SECTION: Municipal College, Portsmouth, "Admiralty Research in Vibration Problems," S. G. Lankester, 7 p.m.——YORKSHIRE BRANCH: GRADUATES' SECTION: Technical College, Huddersfield, "Mechanical Engineering Problems in the Chemical Industry," G. P. Dawson, 7 p.m.

Thurs., Dec. 6th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Mechanical Engineering in the Process Industries," W. F. Carey, "The Training of Craftsmen," John Loxham, 6.45 p.m.——SCOTTISH BRANCH: Royal Technical College, Glasgow, "Technical Education in America," D. S. Anderson and James Ferguson, 7.30 p.m.

Fri., Dec. 9th.—Storey's Gate, St. James's Park, London, S.W.1, "The Measurement and Interpretation of Machinery Noise with Special Reference to Oil Engines," C. H. Bradbury, 5.30 p.m.——N.E. BRANCH: GRADUATES' SECTION: Northern Gas Board Showrooms, Grainger Street, Newcastle upon Tyne, "Brittle Lacquers," H. A. Slyper, 7 p.m.——SCOTTISH BRANCH: Technical College, Dundee, "Some Milestones in a Hundred Years of Marine Engineering," Edward L. Denny, 7.30 p.m.

Institution of Post Office Electrical Engineers

Fri., Dec. 7th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Application of Machinery to the Sorting of Parcels," P. E. C. Smith and H. J. Langton, 5 p.m.

Institution of Structural Engineers

Tues., Dec. 4th.—N. COUNTIES' BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, Film and Slides of "Factory Extension at Silvertown," Frank G. Etches, 6.30 p.m.——N. IRELAND BRANCH: College of Technology, Belfast, "Prestressed Concrete Beams and Slabs," A. H. K. Roberts, 7.30 p.m.

Junior Institution of Engineers

To-day, Nov. 30th.—39, Victoria Street, London, S.W.1, "Some American Windmills," Rex Wailes, 6.30 p.m.

Mon., Dec. 3rd.—Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester, "Power Stations," F. Marshall, 7.30 p.m.

Fri., Dec. 7th.—39, Victoria Street, London, S.W.1, Film Evening, "Arc Welding," 6.30 p.m.

Leeds Metallurgical Society

Thurs., Dec. 6th.—The University, Leeds, Film Night, "Process Heating Equipment," 7 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Fri., Dec. 7th.—Mining Institute, Newcastle upon Tyne, "External Ship Corrosion Due to Bacterial Action," W. S. Patterson, 6.15 p.m.

Royal Aeronautical Society

Thurs., Dec. 6th.—Institution of Civil Engineers, Great George Street, London, S.W.1, "Air Intakes for Gas Turbines," J. Seddon, 6 p.m.

Royal Institution of Chartered Surveyors

Mon., Dec. 3rd.—Institution of Civil Engineers, Great George Street, London, S.W.1, "The Rebuilding of London, 1666–1951," K. Marr-Johnson and T. F. Reddaway, 5.30 p.m.

Society of Engineers

Mon., Dec. 3rd.—Geological Society, Burlington House, Piccadilly, London, W.1, "Some Aspects of Industrial Filtration," R. E. Gray, 5.30 p.m.

Women's Engineering Society

Tues., Dec. 4th.—LONDON BRANCH: 35, Grosvenor Place, S.W.1, "Achievement: Pioneers Then and Now," 7 p.m.

Catalogues

TUFNOL, Ltd., Perry Barr, Birmingham, 22B.—Booklet illustrating the uses of Tufnol.

W. G. PYE AND CO., Ltd., Granta Works, Cambridge.—Catalogue of scientific instruments.

T. NORTON AND CO., Ltd., Birmingham. 1.—Catalogue of press shop and tool-room equipment,

ALMIN, Ltd., Farnham Royal, Bucks.—Souvenir brochure devoted to the Dome of Discovery.

MAGNETIC EQUIPMENT CO., Cosham, Portsmouth.—Leaflet dealing with "Magco" bin vibrators.

GEO. W. KING, Ltd., Hitchin and Stevenage, Herts.—Folder giving details of an electric tractor unit.

W. E. SYKES, Ltd., Staines, Middlesex.—Folder illustrating vertical gear generating machines, Model V.10A.

HEAT ECONOMY, Ltd., 13/21, Hoxton Street, London, N.1.—Leaflet dealing with flue dust blower and suction plant.

SOUTH BEND LATHE WORKS, South Bend 22, Indiana, U.S.A.—Catalogue No. 5102 of new attachments and accessories.

AIR CONTROL INSTALLATIONS, Ltd., Ruislip, Middlesex.—Publication No. G.513, entitled "Foundry Dust Control."

SUNVIC CONTROLS, Ltd., 10, Essex Street, London, W.C.2.—Catalogue describing the range of industrial instruments and controllers being manufactured under licence from Moore Products Company of Philadelphia, U.S.A.

KESTNER EVAPORATOR AND ENGINEERING COMPANY, Ltd., 5, Grosvenor Gardens, Westminster, London, S.W.1.—Leaflet No. 283, describing axial-flow fans for corrosive gases. Leaflet No. 288, describing acid recovery plant.

FRIED. KRUPP, LOCOMOTIVFABRIK, Essen, Germany. English agents: J. M. J. Maus, Ltd., New Broad Street, London, E.C.2.—Leaflet dealing with burnishing apparatus for burnishing the journals of wheel sets for carriages and wagons, tenders and locomotives.